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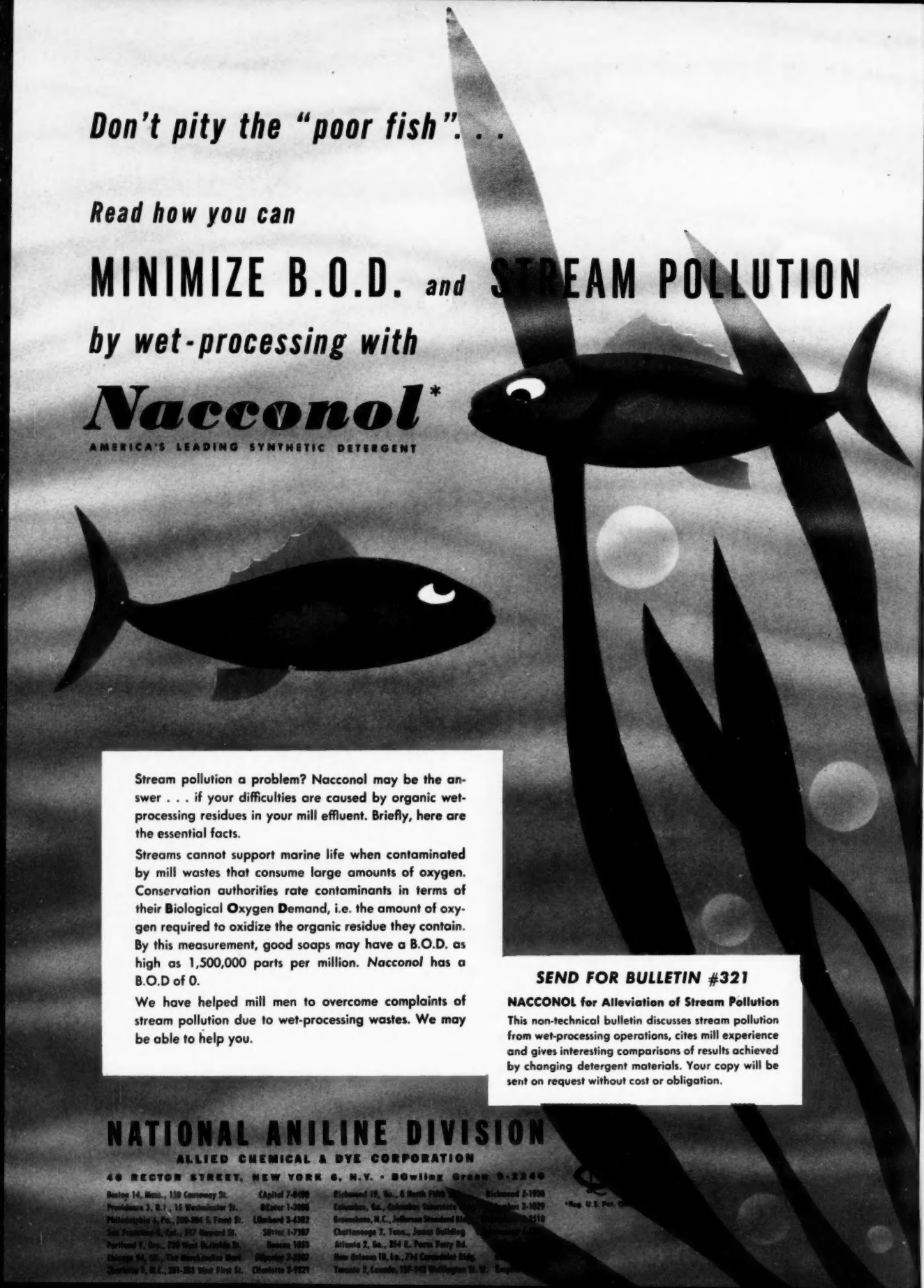
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Proceedings of the
American Association of Textile Chemists and Colorists

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APRIL 14, 1952

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CALENDAR

COUNCIL
April 18, June 13 (New York); September 19 (Philadelphia); November 6 (Boston)

GENERAL RESEARCH COMMITTEE
(See Council dates)

NATIONAL CONVENTIONS
November 6-8, 1952 (Hotel Statler, Boston); September 17-19, 1953 (Hotel Conrad Hilton, Chicago); 1954 (Atlanta, Ga).

HUDSON-MOHAWK SECTION
May 2 (Jack's Restaurant, Albany); June 20 (Annual Outing).

MID-WEST SECTION
April 19 (Hotel Netherlands Plaza, Cincinnati); June 14 (Lake Lawn Lodge, Delavan, Wis); October 4 (Hotel Bismarck, Chicago).

NEW YORK SECTION
April 18, May 16 (Swiss Chalet, Rochelle Park, N J); June 13 (Outing, North Jersey Country Club, Wayne, N J).

NORTHERN NEW ENGLAND SECTION
April 18 (Lowell Textile Institute, Lowell, Mass); May 16 (Andover Country Club, Andover, Mass); June 6 (Outing, Merrimack Valley Country Club, Methuen, Mass); December 6 (Annual Meeting, Lowell Textile Institute).

PHILADELPHIA SECTION
April 25 (Abraham Lincoln Hotel, Reading, Pa); June 13 (Lu Lu Temple Country Club, North Hills, Pa).

PIEDMONT SECTION
April 26 (Clemson Hotel, Clemson, S C); June 6-7 (Ocean Forest Hotel, Myrtle Beach, S C); Sept 13 (Hotel Charlotte, Charlotte, N C).

RHODE ISLAND SECTION
April 25 (Wannamoisett Country Club); May 23 (Providence Engineering Society); June 6 (Outing, Wannamoisett C C); Oct 24 (Providence Engineering Society); December 5 (Annual Meeting, Sheraton-Biltmore, Providence, R I).

SOUTH CENTRAL SECTION
May 17 (Patten Hotel, Chattanooga, Tenn); Aug 22-23 (Outing, Chattanooga Golf & Country Club); December 6 (Patten Hotel).

SOUTHEASTERN SECTION
May 3 (Ralston Hotel, Columbus, Ga); June 6-7 (Outing, Radium Springs, Ga); Sept 13 (Biltmore Hotel, Atlanta).

WESTERN NEW ENGLAND SECTION
May 2 (Ladies Night, Chase Country Club, Waterbury, Conn); June 20 (Outing); Oct 3, Nov 14 and Dec 12 (Rapp's Restaurant, Shelton, Conn).

WNE to Hold Ladies Night at Chase C C

THE site of the annual Ladies Night dinner meeting of the Western New England Section has been changed from Cheshire, Connecticut, to the Chase Country Club, which is on top of Southington Mountain, near Waterbury, Conn. The date for the popular event remains the same, May 2.

Bertil A Ryberg (Procter & Gamble Company), guest speaker for the evening, will show a film entitled, "Leave Less to Luck". In addition, Raymond W Jacoby, AATCC Vice President (New England Region) and 1951 Olney Medalist, will speak briefly on his recent trip to Europe. He reportedly will discuss some new developments in European fabrics that he observed.

Guests are invited. Reservations may be obtained from S V Vaniotis, Ciba Co, Inc, 627 Greenwich St, New York 14, N Y.

AATCC to Participate in Textile Testing Forum

HW STIEGLER, AATCC Director of Research, has officially announced that the Association will participate in the Textile Testing Forum, which will be sponsored by the Quebec Section of the Canadian Association of Textile Colourists and Chemists on April 25 at the Mount Royal Hotel, Montreal, Que. It is also announced that the AATCC plans to show some of the newer pieces of equipment during the Display.

—♦ ♦—

Meeting Report— Southeastern Section

February 23, 1952
Talladega, Alabama

THE Southeastern Section held its first meeting of the year February 23rd at Talladega, Alabama.

One hundred and twenty-eight members heard talks by T A Field, Jr, of the Carbide and Carbon Chemicals Corporation, on "Dyeing Dynel and Related Products," and Henry Millson, Calco Chemical Division, American Cyanamid Company, on "Studies with the Microdyeoscope."

A banquet in the dining room of the Purefoy Hotel preceded the technical session. During the meal, Chairman S Jack Davis rendered a few remarks about the work of the Research Committee, future meetings, the outing, and the necessity for acquiring new members. Francis Webster told of plans for the 1952 outing, which will be held at Radium Springs, Ga, June 6-7.

Additional entertainment at the meeting was furnished by a group of dancers from Anniston, Ala.

—♦ ♦—

Southeastern Section to Meet May 3

THE Southeastern Section will hold its second meeting of the year in the Ralston Hotel, Columbus, Ga, on May 3rd.

The afternoon technical session will feature Donald E Marnon, General Dyestuff Corporation and Irving Welch, American Viscose Corporation, as guest speakers. Mr Marnon will discuss the Marhen Process, after which Mr Welch will talk about the new Avcoset Process.

The evening session will consist of a banquet and business meeting. Samuel L Hayes, National Vice President (Southern Region), is slated to render a few remarks relative to the National Association.

OTHER EVENTS

ACHEMA X
Exhibition Meeting for Chemical Engineering, May 18-25, Frankfort/M, Germany.

AMERICAN CHEMICAL SOCIETY
7th National Chemical Exposition, Sept 9-13, Chicago Coliseum, Chicago, Ill. This will include the 2nd International Art Exhibit.

AMERICAN OIL CHEMISTS SOCIETY
Forty-third Annual Meeting, April 28-30, Shamrock Hotel, Houston, Texas
Short Course industrial trips, July 8-9, 10-11.

AMERICAN SOCIETY FOR QUALITY CONTROL
Sixth Annual Convention, May 22-24, Syracuse, New York.

AMERICAN SOCIETY FOR TESTING MATERIALS
Annual Meeting, June 23-27, 1952, New York, N Y. (The biennial Apparatus and Photographic Exhibits will be held in conjunction with this meeting).

AMERICAN STANDARDS ASSOCIATION
3rd National Standardization Conference, Sept 8-10, Museum of Science and Industry, Chicago, Ill.
34th Annual Meeting, November 19, Waldorf-Astoria, New York, N Y.

BRITISH INDUSTRIES FAIR
May 5-16, London and Birmingham, England.

CANADIAN ASSOCIATION OF TEXTILE COLOURISTS AND CHEMISTS
Annual Meeting (Quebec Section) April 25-26, Mount Royal Hotel, Montreal, Que.

CANADIAN TEXTILE SEMINAR
September 11-13, Queen's University, Kingston, Ont.

FIBER SOCIETY
Meeting: April 16-17, 1952 (Clemson House, Clemson, S C); Sept 10-11 (Princeton, N J).

LEIPZIG FAIR
September 7-17, Leipzig, Germany.

NATIONAL ASSOCIATION OF HOSIERY MANUFACTURERS
41st Knitting Arts Exhibition, April 27-May 1, 1953, Atlantic City Auditorium, Atlantic City, N J.

NATIONAL KNITTED OUTERWEAR ASSOCIATION and UNDERWEAR INSTITUTE
Knitting and Allied Crafts Exposition, April 21-25, Grand Central Palace, New York, N Y.

AMERICAN TEXTILE MACHINERY ASSOCIATION
Exhibit of American Textile Machinery, April 26-May 1, 1954, Atlantic City Exhibition Hall, Atlantc City, N J.

NEW YORK BOARD OF TRADE
26th Annual Meeting: September 25-28, Pocono Manor Inn, Pocono Manor, Pa.

PHI PSI FRATERNITY
49th Annual Convention, May 1-3, Clemson House, Clemson, S C.

PURDUE INDUSTRIAL WASTE CONFERENCE
May 7-9, Purdue Memorial Union, Purdue University, Lafayette, Indiana.

SOCIETE DE CHEMIE INDUSTRIELLE
25th International Congress for Industrial Chemistry, May 18-25, Paris, France.

TEXTILE INSTITUTE
Annual Conference, June 2-6, Edinburgh, Scotland.

Intersectional Contest
Second Prize Winner——

THE CONTINUOUS DYEING OF NEW SYNTHETIC FIBERS*

RHODE ISLAND SECTION

Edward H Gamble

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The objective of this investigation was to develop continuous dyeing methods for fabrics composed of the new synthetic fibers, namely: Dacron, Orlon, Acrilan and Dynel. Two possibilities were considered:

1) The conversion of established non-continuous processes into continuous ones.
2) The development of new processes.

The application of the following classes of dyes was studied:

Acetate dyes with and without carriers.
Acid dyes with and without pretreatments and carriers.
Premetallized dyes with and without pretreatments and carriers.
Vat dyes by pigment, reduced and vat-acid methods.
Leuco esters of vats with and without cuprous-ion pretreatment.

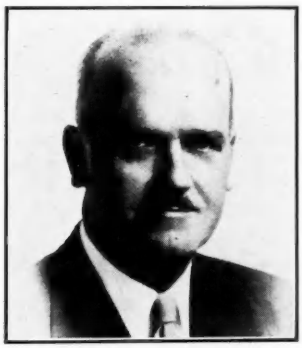
A study of the influence of heat was made on the foregoing. Preliminary experiments showed promising results with vat dyes and their leuco esters. Since fabrics so dyed had superior light and wash fastness, most of the subsequent work was devoted to these classes of dyes.

As this study progressed, several original and practical processes were developed.

Successful plant trials were made by the following methods:

1) A modified method of applying the leuco esters of vat dyes.
2) A method for the continuous application of cuprous ion on acrylic fibers.
3) A process for applying vat dyes to Dacron.
4) A surface-stripping process after dyeing, which improves the crock fastness of vat dyeings.

It was found from this study that selected vat dyes and their leuco esters could be utilized for the practical dyeing of fabrics composed of polyester and acrylic fibers.



W George Parks

INTRODUCTION

THE development of new synthetic fibers during the past few years has been one of the most interesting and important advances in the textile industry. Additions to this field in the years ahead as well as commercialization of those fibers which prove to be most useful and most economical may be expected.

It is convenient to distinguish between new fibers based on natural raw materials and those which are truly synthetic, since this paper deals primarily with the latter type. Manufacturers of four synthetic fibers have recently announced plans to build plants capable of producing millions of pounds of these fibers annually. The four fibers are Dacron, developed by DuPont *(1-5)*; Dynel, developed by Carbide and Carbon Chemicals Corp *(6-8)*; Orlon, developed by DuPont *(9-12)*; and Acrilan, developed by Chemstrand Corp *(13-14)*. Since these four new fibers will be reaching our mills and finishing plants in increasing quantities, we must endeavor to learn how to fabricate, dye and finish them.

It is interesting to note that all four of these fibers are spun from synthetic resins or polymers. In this respect they are somewhat similar to nylon, Vinyon, and Saran, which have already found a place in the textile industry. Not all polymers or resins can be made into useful fibers. Apparently long, straight-chain molecules of high molecular weight are required, which can be oriented and crystallized by stretching, heating, steaming, etc.

Dacron is a condensation polymer made by reacting ethylene glycol with the dimethyl ester of terephthalic acid. The fiber is produced by extruding the molten resin through spinnerets in a manner similar to that used for nylon. The Imperial Chemical Industries produce this fiber in England under the name "Terylene" *(1)*, and they were the first to recognize its potentialities.

Dynel, Orlon, and Acrilan are all addition polymers containing acrylonitrile and are made into fibers by extrusion of resin solutions. Dynel contains 60% vinyl chloride and 40% acrylonitrile and may be considered as a staple form of Vinyon N. Orlon is made from polyacrylonitrile and presumably contains no other monomer than acrylonitrile. The information available on Acrilan indicates that it is made primarily from acrylonitrile but also contains some other chemical, which facilitates dyeing with acid colors.

The physical properties of the synthetic fibers are similar in many respects as illustrated in Table I. It is notable that the tensile strength of the wet fibers approximates that of the fibers when dry. Their elongation values are more like wool than cotton. The low moisture regain of these fibers is significant, since it points up the fact that these materials do not absorb water and are definitely hydrophobic; therefore, they are of consumer value from the standpoint of spot resistance, washability, and quick drying. On

* Presented at the 30th Annual Convention in New York on October 19, 1951.

TABLE I

PHYSICAL PROPERTIES OF SYNTHETIC FIBERS

	Tenacity, Dry	*grams/den Wet as % of dry*	*Elongation %, dry*	*Modulus* grams/den*	*Density*	*Regain 70°F, 65% RH*
Dacron,						
filament	4.4–6.6	90–100	9.0–22	86	1.38	0.5
staple	3.0–3.9	90–100	25–40	20	1.38	0.5
Dynel	2.5–3.0	90–100	35	—	1.28	0.5
Orlon,						
filament	4.0–4.8	90–93	16–21	83	1.18	1.0
staple	—	90–93	—	34	1.18	1.0
Acrilan	3.8	90–100	17	—	1.14	1.6

* times 100

the other hand, this characteristic is a distinct disadvantage in dyeing and wet processing and in the fact that it permits build-up of static charges.

DYEABILITY OF THE SYNTHETIC FIBERS——The dyeing of these new synthetic fibers presents many technical and application problems. Consequently, this subject has received much consideration and study by fiber and dyestuff manufacturers as well as textile processors. Most of the work performed to date has been by intermittent processing, an exception being the Thermosol process developed by Du Pont *(28)*. The purpose of this investigation was to develop practical continuous processes whereby these fibers could be dyed to possess the desired fastness properties.

Cellulose and protein fibers swell in water and exhibit an affinity for many water-soluble ions and molecules, and we depend upon these properties in dyeing them. These new synthetic fibers, on the contrary, are inert in water and show at best a very limited affinity for dyes even at the boil.

Dispersed acetate dyes, which may dissolve or diffuse in organic compounds and resins, as a class show the most affinity for these synthetic fibers *(14-24)*.

The report of Feild and Fremon that certain metallic ions assist in the dyeing of acrylic fibers with certain dyes has been very useful *(25-27)*. These ions, particularly cuprous ion, apparently chelate with the nitrile groups within the fibers and insolubilize the dyes. This "copper technique" is most effective with acid, direct and dispersed acetate colors.

Another technique which has been found quite useful for dyeing these synthetic fibers is the use of swelling agents or carriers. These compounds apparently cause the fibers to swell, at least in the amorphous regions, so that dye molecules can more readily penetrate. p-Phenylphenol appears to be outstanding as a swelling agent, although other phenols, benzoic acid, and monochlorobenzene are among the many materials that have been recommended.

In an effort to obtain fundamental information of greatest usefulness, the work undertaken for this paper was limited to fabrics in each of which only one type of fiber was used. It is recognized, however, that many of the synthetic fibers will find their greatest application in blends, particularly with wool.

At the outset this study was planned to be a supplement to the 1950 R I Intersectional Contest Paper on the continuous dyeing of nylon. Accordingly, all man-made fibers were considered, among which was acetate rayon.

As a supply of acetate was readily available, early work was started on this material, but as the results obtained were largely negative, subsequent efforts were confined to the new synthetic fibers. A résumé of this preliminary study is given herewith:

ACETATE——An extensive series of tests was made in an effort to develop a method of continuous dyeing of acetate fabrics. Both dull and lustrous fibers were used in each test.

The following dyes were used, as previous work indicated some fixation on acetate:

Cloth Fast Yellow 2GC (CI 642)
Brilliant Acid Flavine FF Extra (Pr 224)
Fast Red A (CI 176)
Brilliant Alizarine Fast Blue B
Cloth Fast Blue GN Conc (CI 288)
Cloth Fast Orange G
Benzyl Fast Blue GL Ex Conc (CI 833)
Kiton Brilliant Red B (CI 748)

Solutions contained ½%, 1% and 2% of dye.

To the solutions of the dyes, the following additions were made, based on weight of solution (ows):

1) No additions
2) 2% acetine
3) 3% ammonium sulfocyanide
4) 5% urea
5) 2% formic acid, 85%
6) 6% ammonium sulfocyanide
7) 10% Kromfax Solvent
8) 10% acetine
9) 10% formic acid, 85%
10) 3% Cellosolve
11) 3% Cellosolve + 2% formic acid, 85%
12) 3% ethyl acetate + 2% formic acid, 85%
13) 3% Carbitol acetate + 2% formic acid, 85%
14) 3% ammonium sulfocyanide + 3% ethyl lactate
15) 2% Acetine J Extra
16) 8% solvent—(55% Butyl Cellosolve
(20% glacial acetic acid
(20% formic acid, 85%
(5% sulfuric acid, 66° Bé

Dye solutions were heated to 180°F, cloth was padded through and passed directly into a steam box, where it was steamed for various lengths of time as follows: 15 seconds, 1 minute, 5 minutes, and 15 minutes. The samples were rinsed in cold water and dried.

A part of each sample was tested in a 0.5% soap solution for ½ hour at 160°F. Samples before and after the wash test were evaluated.

The results obtained varied greatly. Some of the dyes were precipitated by certain of the additions made to the dyebaths; the effect of the different additions varied from dye to dye; and no addition was found that gave good fixation and color yield with all dyes tested.

With some additions and some dyes, as the steaming time was increased, the color yield and wash fastness increased, whereas with other dyes and the same additions, results were poor regardless of steaming time. In some cases the color yield and wash fastness were good after steaming for 1 minute.

Results obtained with the various dyes were as follows:

Fast Red A gave good color yield and wash fastness with a number of additions.

Cloth Fast Yellow 2GC did not give more than fair color yield in any test.

Cloth Fast Orange G gave good color yield with a number of additions and with 1 minute steaming, but wash tests were only fair regardless of addition or steaming time.

Brilliant Alizarine Fast Blue B, Benzyl Fast Blue GL Ex Conc, Cloth Fast Blue GN Conc, Brilliant Acid Flavine FF Extra and Kiton Brilliant Red B did not give better than fair results with any addition or any time of steaming.

To summarize: Results were very selective as to dye, addition and steaming time, and, although good dyeings were obtained in isolated cases, there was no indication that any one set of conditions could be established to yield an acceptable process. There was very little difference whether lustrous or dull acetate was run.

PRELIMINARY TRIALS

Information published to date indicated that, in general, acetate dyes exhibited the greatest affinity for the four newer synthetic fibers of this study: Orlon, Dacron, Dynel, and Acrilan. Accordingly, various tests were made with acetate dyes under the following conditions: beaker dyeings; padding and steaming; and the preceding method in conjunction with carriers or a pretreatment. As these preliminary trials were not too encouraging, they will be reported upon collectively for the four fibers. For subsequent studies where isolated cases gave outstanding results, they will be reported under the individual fibers.

ACETATE DYES

A) *Beaker dyeings*:

The following dyes were selected primarily because of their better-than-average fastness to light when dyed on acetate rayon. Dyeings on acetate rayon were used as a

TABLE II

ACETATE COLORS DYED IN BEAKER

Color		Orlon	Acrilan	Dynel	Dacron	Acetate	Nylon
Eastone Yellow GLF	Yield	fair	excellent	excellent	fair	excellent	fair
	Shade	red & dull	red & dull	dull	red & dull	true shade	true shade
	Wash Test*	excellent	excellent	excellent	excellent	good	very poor
	Light**	good	good	good	good	good	good
	Crocking	excellent	excellent	excellent	excellent	excellent	excellent
Celliton Fast Pink BA	Yield	fair	very good	excellent	excellent	excellent	excellent
	Shade	blue-dull	blue-dull	bluer & tr duller	bluer	true shade	bluer
	Wash Test*	poor	poor	good	very good	poor	very poor
	Light**	poor	poor	poor	poor	poor	poor
	Crocking	poor	poor	poor	fair	excellent	excellent
Celliton Fast Blue AF	Yield	poor	fair	good	poor	excellent	excellent
	Shade	green-dull	green-dull	dull	dull	true shade	green-dull
	Wash Test*	fair	fair	fair	excellent	excellent	fair
	Light**	poor	poor	poor	poor	poor	poor
	Crocking	poor	poor	poor	fair	excellent	excellent

* AATCC #3 synthetic-fiber wash test
** 40 hours Fade-Ometer

standard in comparing yield, shade, fastness to crocking and washing.

Eastone Yellow GLF
Celliton Fast Pink BA—CF (Pr 234)
Celliton Fast Blue AF Ex Conc (Pr 227)

Amounts of dyes used were 2% and 4% calculated on weight of fiber (owf).

Beaker dyeings were made in the conventional manner. The results are shown in Table II.

Results: In no case was a satisfactory dyeing obtained. Color yields varied from very poor to very good; there was generally a shade change compared with the same dye on acetate; crocking varied from very slight to heavy, and wash tests were not passable from the standpoints of shade change and staining of nylon, wool and silk.

B) *Effect of Padding and Steaming*

Procedure: 1 and 2% solutions of acetate dyes were padded at 180°F, steamed 15 seconds, 1 minute, 2 minutes and 5 minutes. The same dyes were used as in the beaker dyeings above.

The dyes were applied to Acrilan, Dacron, Dynel and Orlon by the above-mentioned procedure. For a comparison acetate and nylon fabrics were included. (See Table III)

The yield varied from fair to good, and the shades obtained were dull and off-tone, as compared with acetate and nylon.

The fastness to washing was improved by longer steaming, but was not equal to that on acetate. The fastness to light was not improved by longer steaming and was generally poor, except with Eastone Yellow GLF. Crocking results were generally poor with these dyes.

Because of the dull shades obtained, the poor fastness to washing, and in general the lack of light fastness, it did not appear practical to apply acetate dyes continuously to these fibers (see Table III).

C) *Effect of Pretreatment*

As there was a possibility that pretreatment might improve the results obtained, this field was investigated. Dyes used:

Celliton Fast Red GGA Ex Conc (Pr 236)
Celliton Fast Blue FFRS Ex (Pr 228)

Samples of fabrics composed of the various fibers were padded through 5% solutions of the following compounds and then dried: p-phenylphenol, benzoic acid, monochlorobenzene, and methyl salicylate.

The treated cloth was then padded and steamed as previously. The results are shown in Table IV. The color yield on Orlon was very poor. On Dacron, Dynel and Acrilan the color yield, light, wash, and crock fastness were quite comparable with the results obtained on nylon. This method of application did look promising, but as developments with other types of dyes indicated the possibility of producing dyeings with better fastness properties, subsequent efforts were devoted to that phase of the study, which will be described hereafter.

TABLE III

ACETATE COLORS BY STEAMING

Color		Orlon	Acrilan	Dynel	Dacron	Acetate	Nylon
Eastone Yellow GLF	Yield	good	very good	very good	very good	excellent	excellent
	Shade	very dull	red & dull	dull	red & dull	true shade	true shade
	Wash Test*	poor	good	fair to poor	poor	good	very poor
	Light**	good	good	good	good	good	good
	Crocking	poor	poor	fair	poor	excellent	poor
Celliton Fast Pink BA	Yield	fair	fair	very good	good	excellent	fair
	Shade	very dull	very dull	dull	blue & dull	true shade	bluer
	Wash Test*	poor	poor	fair to poor	fair to poor	fair-poor	poor
	Light**	poor	poor	poor	poor	poor	poor
	Crocking	poor	poor	poor	poor	poor	poor
Celliton Fast Blue AF	Yield	good	good	good	excellent	excellent	fair
	Shade	red & dull	green & dull	green & dull	trace dull	true shade	greener
	Wash Test*	very poor	very poor	fair to poor	poor	poor	fair
	Light**	poor	poor	very poor	poor	poor	poor
	Crocking	poor	poor	very poor	poor	poor	poor

* AATCC #3 synthetic fiber wash test
** 40 hours Fade-Ometer

ACID AND PREMETALLIZED DYES

Available published data indicated the potential utility of certain acid dyes on these fibers. Accordingly, various tests were made as follows:

A) *Beaker Dyeings*

Dyes used:

Xylene Lt Yellow 2G (CI 639)
Croceine Scarlet MOO (CI 252)
Alizarine Sky Blue BS (CI 1088)

These dyes were selected because of their fastness properties when dyed on nylon.

Dyeings were made at 2% and 4% on all fibers by the conventional method, and comparisons were made against similar dyeings on nylon. The results are given in Table V.

On Orlon, Dynel and Dacron these dyes gave little or no yield. On Acrilan the yield was very comparable with that on nylon; the crocking, both wet and dry, ranged from light to heavy, as opposed to none on nylon; in No. 2 and No. 3 wash tests, staining of wool, silk, and nylon ranged from slight to appreciable, together with little or no change in shade.

B) *Effect of Padding and Steaming*

a) Acid Dyes

Procedure: 1 and 2% solutions of acid dyes were padded at 180°F, steamed 15 seconds, 1 minute, 2 minutes and 5 minutes. The following dyes were used:

Xylene Lt Yellow 2G (CI 639)
Croceine Scarlet MOO (CI 252)
Alizarine Sky Blue BS (CI 1088)

The above dyes were applied to Acrilan, Dacron, Dynel and Orlon by the aforementioned procedure. For a comparison, acetate and nylon fabrics were included (see Table VI).

The yield varied from fair to good, and the shades obtained were dull and off-tone, as compared with acetate and nylon.

The fastness to washing was improved by longer steaming, but still poor to the No. 3 synthetic-fiber wash test. The fastness to light was generally very poor. It was not improved by longer steaming. Alizarine Sky Blue BS did, however, show good light fastness on Orlon and Dacron. Crocking results were generally poor with these dyes. Because of the dull shades obtained and poor fastness to washing, light and crocking, it did not appear practical to apply acid dyes continuously to these fibers.

b) Premetallized Dyes

TABLE IV

CONTINUOUS DYEING ACETATE COLORS WITH ASSISTANTS

Dye	*Assistant*		*Orlon Fil*	*Dacron Fil*	*Nylon Fil*	*Dynel*	*Acrilan*	*Dacron, Spun*
Acetate Red GG	none	Depth	none	fair	good	good	good	fair
		Wash	—	excellent	fair	fair	fair	fair
		Light	—	poor	poor	poor	poor	poor
		Crock	—	excellent	excellent	excellent	poor	good
		S-Crock	—	excellent	excellent	excellent	fair	excellent
	benzoic acid	Depth						
		Wash						
		Light	Identical with plain					
		S–Crock						
	para-phenyl-phenol	Depth	trace	fair	good	good	good	fair
		Wash	—	excellent	fair	good	fair	fair
		Light	—	v poor	poor	poor	poor	poor
		Crock	—	excellent	excellent	excellent	good	good
		S–Crock	—	excellent	excellent	excellent	good	excellent
	mono-chlor-benzene	Depth	trace	fair	good	good	good	good
		Wash	—	excellent	fair	good	fair	fair
		Light	—	poor	poor	poor	poor	poor
		Crock	—	good	excellent	good	fair	good
		S–Crock	—	good	excellent	excellent	fair	good
	methyl salicylate	Depth	trace	good	good	good	good	good
		Wash	—	excellent	fair	fair	fair	fair
		Light	—	poor	poor	poor	poor	poor
		Crock	—	good	excellent	good	fair	good
		S–Crock	—	excellent	excellent	excellent	fair	good
Acetate Blue FFR	none	Depth	trace	fair	fair	good	good	good
		Wash	—	fair	good	fair	fair	fair
		Light	—	fair	poor	poor	poor	poor
		Crock	—	excellent	excellent	good	fair	good
		S–Crock	—	excellent	excellent	excellent	good	excellent
	benzoic acid	Depth	trace	good	good	good	good	good
		Wash	—	good	good	good	good	good
		Light	—	poor	fair	poor	poor	poor
		Crock	—	excellent	excellent	good	fair	good
		S–Crock	—	excellent	excellent	excellent	good	excellent
	para-phenyl-phenol	Depth	trace	good	good	fair	fair	good
		Wash	—	good	good	fair	fair	good
		Light	—	poor	poor	poor	poor	poor
		Crock	—	excellent	excellent	good	fair	excellent
		S–Crock	—	excellent	excellent	excellent	good	excellent

The following premetallized dyes were tested by the pad-steam method:

Capracyl Yellow N
Neolan Blue GG (Pr 144)

Samples of the fabrics were padded through a 1% solution of the dye at 180°F, steamed for 5 minutes, rinsed, soaped 5 minutes at 160°F, rinsed and dried. For purposes of comparison similar trials were made on nylon. The results of these tests are given in Table VII.

There was practically no color yield on Orlon and Dacron. On Dynel the results showed some promise, while on Acrilan they were comparable to those on nylon.

C) *Effect of Pretreatment with Acid and Pre-metallized Dyes*

Samples of the four synthetic fibers together with nylon were padded through 5% solutions of the following compounds and dried: p-phenylphenol and benzoic acid.

Pretreated cloth was padded through 1% solutions of the following dyes at 180°F, steamed for 5 minutes, rinsed, soaped 5 minutes at 160°F, rinsed and pressed dry:

Crocein Scarlet N (CI 252)
Alizarine Rubinol R (CI 1091)
Polar Yellow 2G (CI 642)
Fast Light Yellow GG (CI 639)
Capracyl Yellow N
Neolan Blue GG (Pr 144)

The acid dyes (first four listed above) gave little or no yield on any fiber, with the

TABLE V

ACID COLORS DYED IN BEAKER

Color	*Yield*	*Orlon*	*Acrilan*	*Dynel*	*Dacron*	*Acetate*	*Nylon*
Xylene Light Yellow 2G CI 639	Yield		good				excellent
	Shade	no	red & dull	no	no	no	true shade
	Wash Test*	affinity	excellent	affinity	affinity	affinity	excellent
	Light**		poor				good
	Crocking		fair to poor				excellent
Crocein Scarlet MOO CI 252	Yield		excellent				excellent
	Shade	no	true shade	no	no	no	true shade
	Wash Test*	affinity	good	affinity	affinity	affinity	good
	Light**		poor				fair to good
	Crocking		poor				fair
Alizarine Sky Blue BS CI 1088	Yield		excellent				excellent
	Shade	no	green & dull	no	no	no	true shade
	Wash Test*	affinity	poor	affinity	affinity	affinity	poor
	Light**		fair				good
	Crocking		poor				excellent

* AATCC #3 synthetic fiber wash test
** 40 Hours Fade-Ometer

TABLE VI

ACID COLORS BY STEAMING

Color		*Orlon*	*Acrilan*	*Dynel*	*Dacron*	*Acetate*	*Nylon*
Xylene Light Yellow 2G C I 639	Yield	good	good	good	good	good	excellent
	Shade	red & dull	red & dull	sli duller	sli duller	redder	true shade
	Wash Test	very poor	very poor	very poor	very poor	very poor	fair
	Light	very poor	very poor	very poor	very poor	very poor	good
	Crock	very poor	very poor	very poor	very poor	very poor	very poor
Crocein Scarlet MOO C I 252	Yield	good	excellent	good	good	poor	excellent
	Shade	dull	dull	dull	dull	very blue & dull	true shade
	Wash Test	very poor	very poor	very poor	very poor	very poor	good
	Light	very poor	very poor	very poor	very poor	very poor	fair to good
	Crock	very poor	very poor	very poor	very poor	very poor	very poor
Alizarine Sky Blue BS C I 1088	Yield	good	good	poor	fair	fair	excellent
	Shade	sli dull	sli dull	green & dull	light & dull	lighter	true shade
	Wash Test	fair to poor	fair to poor	very poor	very poor	fair to poor	good
	Light	fair	fair	poor	good	poor	good
	Crock	fair	fair	fair	fair	good	good

TABLE VII

PREMETALLIZED COLORS BY STEAMING WITH & WITHOUT CARRIERS

Dye	Carrier		Orlon Fil	Dacron Fil	Nylon Fil	Dynel	Acrilan	Dacron Spun
Capracyl Yellow N	none	Depth	none	none	fair	fair	good	trace
		Wash	—	—	excellent	good	good	—
		Light	—	—	fair	fair	fair	—
		Crock	—	—	excellent	excellent	fair	—
		S-Crock	—	—	excellent	excellent	good	—
	benzoic acid	Depth	none	trace	fair	fair	good	trace
		Wash	—	—	excellent	good	good	—
		Light	—	—	poor	poor	poor	—
		Crock	—	—	excellent	excellent	good	—
		S-Crock	—	—	excellent	excellent	good	—
	paraphenyl-phenol	Depth	none	trace	fair	good	good	poor
		Wash	—	—	good	good	good	excellent
		Light	—	—	poor	poor	poor	poor
		Crock	—	—	excellent	good	fair	good
		S-Crock	—	—	excellent	excellent	good	excellent
Neolan Blue GG	none	Depth	none	none	good	poor	good	trace
		Wash	—	—	excellent	good	excellent	—
		Light	—	—	poor	poor	fair	poor
		Crock	—	—	excellent	—	fair	—
		S-Crock	—	—	excellent	excellent	good	—
	benzoic acid	Depth	none	none	good	trace	good	trace
		Wash	—	—	excellent	—	excellent	—
		Light	—	—	poor	—	poor	—
		Crock	—	—	excellent	—	good	—
		S-Crock	—	—	excellent	—	good	—
	paraphenyl-phenol	Depth	none	none	good	trace	good	trace
		Wash	—	—	excellent	—	excellent	—
		Light	—	—	poor	—	poor	—
		Crock	—	—	excellent	—	fair	—
		S-Crock	—	—	excellent	—	good	—

exception of nylon, under any conditions of the test.

The results with the two premetallized dyes are given in Table VII. These show practically no color yield on Orlon or Dacron. With Capracyl Yellow N the results on Dynel and Acrilan were comparable with those on nylon. When Neolan Blue 2G was dyed there was practically no color yield on Dynel with either pretreatment. The dyeings on Acrilan were comparable to those on nylon.

As the dyeings on Acrilan showed possibilities, additional tests were made as follows:

Eight padding solutions were prepared, each containing 0.5% Crocein Scarlet N Extra; small swatches of Acrilan, with wool for control, were padded and with one exception steamed one minute. After steaming the samples were rinsed in cold water, soaped 5 minutes at 180°F, and pressed dry.

1) No acid (no steaming)
2) No acid
3) 0.1% Sulfuric acid
4) 1.0% Sulfuric acid
5) 0.1% Nitric acid
6) 0.1% Sulfanilic acid
7) 1.0% Sulfanilic acid
8) 1.0% d-Gluconolactone

Tests: Each dyed sample was tested for wash fastness (No. 3) and crocking before and after the wash test.

Results: No color was retained by samples without acid. Greatest depth was obtained with 1.0% sulfuric, and the other acids were effective in decreasing order: 1.0% sulfanilic, 0.1% sulfuric, 0.1% nitric, 1.0% d-gluconolactone, and 0.1% sulfanilic. Both sulfanilic acid and the lactone showed promise as practical, noncorrosive acids. Crocking was improved after the wash test but was still not satisfactory.

EFFECT OF STEAMING TIME——A padding solution was prepared containing 0.5% Grocein Scarlet N Extra and 0.1% sulfuric acid at 180°F. Small swatches of Acrilan, with wool cloth control, were padded and then steamed for 12 seconds, 30 seconds, 60 seconds and 5 minutes. After steaming, each sample was rinsed in cold water, soaped 5 minutes at 160°F and pressed dry.

Tests: Each dyed sample was tested for washfastness (No. 3) and crocking before and after the wash test.

Results: Very little difference could be observed on Acrilan steamed for different times. The shortest time, 12 seconds, could be considered as the simplest and most practical.

EFFECT OF A MOLTEN-METAL BATH——A 2% solution of Palatine Fast Yellow GRNA-CF (Pr 316) with the addition of 2% of formic acid, 85%, was made. Samples of Orlon, Dacron, Acrilan and nylon were padded through this solution and passed directly into a molten-metal bath at 212°F, rinsed and dried. A portion of each sample was then heat-treated at 350°F for 55 seconds.

Color yield and fastness to washing, light and crocking were poor in every instance.

The same series of tests was repeated on the same fabrics, which had been pretreated by padding through a 2% solution of salicylic acid and drying. Here again, the results were negative, and the pretreatment showed no improvement.

EFFECT OF CUPROUS IONS ON ACRYLIC FIBERS——Since cuprous ions have been found very effective in the batch dyeing of Dynel and Orlon with acid colors, it was considered worthwhile to see if the same results could be obtained in a contin-

TABLE VIII

EFFECT OF CUPROUS IONS ON ACRYLIC FIBERS
1% CROCEIN SCARLET, 5-MIN STEAMING

	Orlon		Acrilan		Dynel		Wool
	Plain	Cu+	Plain	Cu+	Plain	Cu+	Control Cu+
Depth	none	slight	light	heavy	light	medium	heavy
Wash	—	excellent	excellent	good	excellent	good	poor
Light	—	fair	poor	(browns)	poor	(browns)	good
Crocking	—	good	excellent	poor	fair	fair	fair
S-Crocking	—	good	excellent	fair	excellent	excellent	excellent

1% CROCEIN SCARLET, 1% ACID, STEAMED 2 MINUTES

	Acrilan			Dynel			Wool
	Plain	Cu+	p-phenyl	Plain	Cu+	p-phenyl	Plain
Depth	good	dark	fair	light	medium	light	good
Wash	fair	good	fair	excellent	good	excellent	poor
Light	fair	(browns)	fair	poor	browns	poor	good
Crocking	poor	fair	poor	good	fair	good	—
S-Crocking	fair	good	fair	excellent	excellent	excellent	excellent

uous pad-steam process. Small swatches of Dynel, Orlon and Acrilan were boiled together in a solution containing 10% copper sulfate, 4% Sulfoxite C and 1% acetic acid, owf. The samples were then padded simultaneously through a 1% solution of Crocein Scarlet at 180°F containing 1% sulfuric acid, steamed for 5 minutes, rinsed, soaped 5 minutes at 160°F, and air-dried.

Tests: All dyed samples were tested for washfastness (No. 3) lightfastness (20 and 40 hrs), and crocking before and after the wash test. Results are shown in Table VIII.

Pretreatment with cuprous ion markedly increases the depth of shade obtainable by pad-steam dyeing. The shade obtained is dull and not like the color expected on wool. Lightfastness is poorer on synthetics than on wool and cuprous treatments seem to cause browning rather than fading of the shade. Dyeing of Acrilan may greatly be affected by presence of acid. p-Phenylphenol assists dyeing of Dynel and a truer shade is obtained than with copper.

CUPROUS-ION—CONTINUOUS PROCESS——Preliminary tests had shown cuprous ions to be quite effective in increasing dye take-up in a pad-steam process. It was considered desirable to determine whether the cuprous ion could be applied by steaming, thus permitting a continuous, although two-stage, dyeing method. Earlier work had indicated that simultaneous application of cuprous ion and dye is not practical.

A padding solution was prepared at 70°F containing 10% copper sulfate, 2% Sulfoxite C, 2% hydrosulfite and 1% Duponol ME. Samples were padded through this mixture and treated as follows:

1) Air-dried.
2) Oven dried at 160°F.
3) Steamed 12 secs.
4) Steamed 60 secs.
5) Steamed 5 min.

All samples were allowed to dry and were then padded with a solution of 1% Brilliant Croceine 3BA-CF containing 1% sulfuric acid at 180°F. All samples were steamed 1 min, rinsed in cold water, soaped 5 min at 160°F, and pressed dry.

FIBERS: The following fabrics were included in this series: Orlon filament taffeta, Orlon staple, Dynel staple, Acrilan, and wool (control).

Results: The effect of cuprous ions was again outstanding. Differences were not pronounced between various drying and steaming treatments to fix the cuprous ion. The best treatment seems to be 12-second steaming of the copper solution. The wash fastness is as good as can be expected for this dye, but the crocking of the staple fibers is unsatisfactory.

VAT DYES ON DACRON

An application of continuous methods for dyeing Dacron with vat dyes has never been described in the literature with the exception of the method reported in the *DuPont Technical Bulletin (28)* and by P L Meunier

TABLE IX

VAT COLORS BY VAT-ACID PROCESS

Color		*Orlon*	*Acrilan*	*Nylon*	*Dacron*	*Cotton*	*Dynel*
Olive Green B Type Pr 293	Depth	good	excellent	good	fair	excellent	good
	Wash	good	excellent	good	good	excellent	good
	Light	good	good	poor	excellent	excellent	good
	Crock	fair	fair	good	good	fair	fair
Jade Green Type CI 1101	Depth	good	excellent	good	good	excellent	good
	Wash	good	good	good	good	excellent	good
	Light	excellent	excellent	good	good	excellent	good
	Crock	fair	poor	good	fair	poor	good
Yellow GC Type Pr 9	Depth	fair	good	poor	fair	excellent	good
	Wash	fair	excellent	fair	good	excellent	good
	Light	poor	poor	poor	fair	poor	poor
	Crock	fair	poor	good	fair	good	fair
Brilliant Orange RK Type Pr 116	Depth	fair	good	fair	good	excellent	good
	Wash	poor	fair	poor	good	good	fair
	Light	good	good	poor	good	good	good
	Crock	fair	poor	good	fair	fair	fair
Yellow GK Type CI 1132	Depth	good	excellent	good	good	good	good
	Wash	fair	fair	poor	fair	good	good
	Light	good	good	poor	fair	fair	good
	Crock	fair	poor	fair	fair	fair	fair
Golden Orange RRT Type CI 1098	Depth	good	excellent	good	good	good	good
	Wash	good	fair	good	good	fair	good
	Light	good	good	poor	good	good	good
	Crock	poor	poor	fair	fair	fair	poor
Golden Orange 3G Pr 290	Depth	poor	good	good	fair	excellent	—
	Wash	excellent	excellent	fair	fair	good	—
	Light	excellent	good	poor	good	excellent	—
	Crock	good	fair	good	good	good	—
Red RK CI 1162	Depth	fair	fair	good	good	excellent	fair
	Wash	fair	poor	good	poor	good	good
	Light	good	good	poor	good	excellent	good
	Crock	fair	poor	fair	fair	fair	fair
Brown G	Depth	poor	excellent	excellent	good	excellent	good
	Wash	fair	good	good	excellent	good	good
	Light	good	fair	fair	excellent	good	good
	Crock	poor	poor	good	fair	poor	poor
Khaki 2G	Depth	good	excellent	good	good	excellent	good
	Wash	good	excellent	good	good	good	excellent
	Light	good	fair	good	good	excellent	good
	Crock	poor	poor	fair	poor	poor	fair
Olive R	Depth	poor	excellent	good	good	excellent	fair
	Wash	poor	fair	good	good	fair	good
	Light	fair	fair	poor	good	good	fair
	Crock	fair	poor	good	poor	fair	poor
Direct Black 3G	Depth	fair	excellent	good	good	excellent	fair
	Wash	good	excellent	excellent	good	excellent	good
	Light	good	good	poor	fair	excellent	fair
	Crock	fair	poor	good	poor	fair	poor
Red FBB Pr 296	Depth	poor	fair	good	good	excellent	—
	Wash	good	excellent	good	good	excellent	—
	Light	good	good	poor	good	good	—
	Crock	poor	poor	fair	fair	poor	—
Pink R Pr 109	Depth	poor	excellent	excellent	excellent	excellent	—
	Wash	poor	excellent	good	poor	good	—
	Light	good	good	poor	good	poor	—
	Crock	fair	poor	fair	fair	fair	—
Violet BN CI 1163	Depth	poor	poor	good	poor	excellent	—
	Wash	poor	poor	excellent	poor	excellent	—
	Light	excellent	fair	poor	good	excellent	—
	Crock	good	good	excellent	excellent	good	—
Brilliant Violet 3B Pr 288	Depth	poor	good	good	good	excellent	—
	Wash	good	excellent	good	good	excellent	—
	Light	good	good	poor	good	excellent	—
	Crock	poor	poor	good	fair	fair	—
Blue 2BD CI 1184	Depth	poor	good	good	good	excellent	—
	Wash	good	excellent	fair	poor	excellent	—
	Light	good	good	poor	good	fair	—
	Crock	poor	poor	fair	poor	fair	—
Midland Vat Blue R CI 1183	Depth	fair	excellent	excellent	good	excellent	—
	Wash	fair	fair	fair	excellent	excellent	—
	Light	poor	good	poor	poor	poor	—
	Crock	poor	poor	poor	fair	fair	—
Blue BCS CI 1113	Depth	fair	good	good	good	excellent	—
	Wash	good	fair	poor	fair	good	—
	Light	excellent	excellent	good	excellent	excellent	—
	Crock	poor	poor	fair	fair	poor	—
Hydron Blue R CI 969	Depth	excellent	excellent	excellent	excellent	excellent	—
	Wash	good	excellent	good	excellent	good	—
	Light	poor	poor	poor	poor	poor	—
	Crock	poor	poor	fair	fair	poor	—

and H F Clapham in the *DuPont Technical Laboratory Bulletin (29) (30)*. Accordingly, a systematic study of continuous methods of application was started. The methods studied included all the methods used for cotton and additional pretreatments and aftertreatments. The use of carriers or swelling agents was also studied in the course of the investigation.

It was hoped that this study would reveal methods that would show enough promise to warrant plant trials. The results were highly satisfactory and successful commercial dyeings were made continuously by original methods.

In the course of the study, it was discovered that the major problem in the use of vat dyes with Dacron——namely, fastness to crocking——could be eliminated. Plant dyeings were made with vat dyes by a continuous process that showed excellent fastness to light and washing and no crocking, wet or dry.

EXPERIMENTAL——All dyeings made were tested for fastness according to the following procedures:

a) Washing Fastness——No. 3 AATCC wash test for manufactured organic fibers.
b) Light Fastness —— Standard Fade-Ometer.
c) Crock Fastness —— Standard Crockmeter (10 turns wet and dry).
d) Surface Stripping Test (see next paragraph).

A characteristic of the dyeing of synthetic fibers is that temperatures near the boiling point must be employed. If true dyeing requires high temperatures, then the removal of dye by stripping should also require high temperatures. Therefore, if vat-dyed synthetic fabrics are treated at lower than dyeing temperatures with chemicals to make the dyes soluble, any loose surface dye can dissolve off without appreciably affecting the remaining portion that is properly fixed. Accordingly, a laboratory method called the "surface stripping test" was developed and was applied as follows:

Vat-dyed Dacron was treated with 1% caustic soda and 1½% sodium hydrosulfite in a beaker at 120°F for 5 to 10 minutes with stirring. The sample was then rinsed and dried. In most instances all the surface dye bled off, leaving only the dye that was well penetrated into the fibers. This phenomenon is particularly striking with dyes that show a change in color on reduction. For instance, cotton dyed with Jade Green and then reduced by a treatment as described above turned blue, whereas a Dacron dyeing stayed green even though the surface dye bled off and turned the solution a characteristic blue. With most vat dyes there is very little color change of the penetrated dye during this treatment, although some vat dyes show a slight change. When all the surface dye is stripped off, a repetition of this treatment shows no discoloration of the test solution.

	Before Heat Treatment					After Heat Treatment				
Vat Dye	Color Yield	Wash Fastness	Lt Test Hours	Crock Fastness Dry	Crock Fastness Wet	Color Yield	Wash Fastness	Lt Test Hours	Crock Fastness Dry	Crock Fastness Wet
Pink R (Pr 209)	poor	good	70	fair	fair	fair/good	good	50	good	good
Orange RRT (CI 1098)	poor	good	70	good	good	fair yellower	good	60	good	good
Red FBB (Pr 296)	poor	good	70	good	good	fair	good	70	good	good
Jade Green (CI 1101)	poor	good	70	fair	fair	fair bluer	good	30	good	good

A variation of this test was used, as follows: Small cuttings of equal size of dyed Dacron and white cotton were treated with the above test solution in a Launder-Ometer jar. The jar was placed in the Launder-Ometer, which was operated for 15 minutes at 120°F. The samples were removed, rinsed and dried. Observation showed that color was transferred from the Dacron to the cotton, and the amount of true dyeing could be measured by observing the depth of dyeing on the cotton test sample. If the cotton remained uncolored, the Dacron dyeing was excellent and well penetrated. This was verified by photomicrographs of the dyed fiber.

APPLICATION OF VAT DYES——*Twenty Vat Dyes by the Vat-Acid Method*

Each dye was prepared as an acid leuco at a concentration of 4 oz/gal by reducing in caustic and hydro and then adding acetic acid. The fabrics were padded through this solution at 120°F, batched, then repadded through caustic and hydro at 100°F and immediately steamed for 12 seconds. After steaming, the samples were rinsed in cold water, soaped 1 minute at 160°F and air-dried. For comparison, cotton broadcloth and nylon taffeta were included in the tests. Each dyed sample was tested for washfastness (No. 3), lightfastness (20 and 40 hrs), and crocking.

The fastness properties varied with the dyes. On the whole, Dacron and cotton showed good light and wash resistance. The lightfastness on nylon was poor. Crocking on all fibers was poor to fair. The results are shown in Table IX.

Dacron Filament Padded with Vat Acid and Reduced on Molten-Metal Machine

Type of Dye: Vat acid (4 oz/gal dye)
Pretreatment: None
Dyeing Method: Pad acid leuco dye, dry at 220° F, rereduce in molten metal at 212° F with one-third of original dye.
Aftertreatment: Heat treatment, 55 secs at 350° F, followed by light soaping.

Results may be seen in the table at the top of this page.

In observing these results, we find the color yield to be poor-fair, however, as a group, the fastness is good.

DACRON DYED CONTINUOUSLY WITH LEUCO ESTERS——Ten dyes were run as follows:

Each dye was made up at 2 oz/gal with sodiom nitrite, salt and sodium carbonate and padded on the fabric with 2 dips and 2 nips at 160°F. The samples were air-dried, padded through cold 7°Tw sulfuric acid, rinsed, soaped 5 min at 120°F, rinsed and ironed dry. The brown dye was used at 4 oz/gal, and urea was added to the bath with the Orange IRKL. Thiourea was added for Green IB and Blue IBC.

The following fibers were treated simultaneously in this series: cotton, nylon, and Dacron.

Each dyed sample was tested for washfastness (No. 3) lightfastness (20 and 40 hrs), and crocking before and after washing. In general the wash and light tests on Dacron were good compared with cotton. Crocking was fair to poor on most samples. The results are shown in Table XIV.

Additional methods were tried as follows:

#1 Pad dye and nitrite in 1st pad box, phosphoric acid in 2nd pad box, steam 12 secs, rinse, dry and heat-treat.
#2 Pad dye and nitrite, dry and heat-treat. Pad through phosphoric acid, steam 12 secs, rinse and dry.
#3 Pad dye and nitrite in 1st pad box, sulfuric acid in 2nd pad box, rinse, dry and heat-treat.
#4 Pad dye and nitrite, dry and heat-treat. Pad through sulfuric acid, rinse and dry.

Method #1 appeared to show the best promise, and was used in the dyeings that follow:

Pretreatment: None
Dyeing Method: Pad-steam — 1st box dye and nitrite at 140° F, 2nd box 3.86 oz/gal phosphoric acid, 85% — steam 12 secs, rinse, soap lightly and dry.
Aftertreatment: Heat treatment 55 secs at 350° F.

These results may be seen in the table at the top of the next page.

The results from a laboratory standpoint seemed promising for light and medium shades.

Added soaping after dyeing improved crocking slightly.

EFFECT OF SWELLING AGENTS——One swelling agent was tried, namely, p-phenylphenol, in the aforementioned trials

Leuco Ester	Before Heat Treatment: Color Yield	Wash Fastness	Light Test Hours	Crock Fastness: Wet	Dry	After Heat Treatment: Color Yield	Wash Fastness	Light Test Hours	Crock Fastness: Wet	Dry
Brill Orange IRKL	poor	good	over 20	fair	fair	fair yellower	fair/good	20	fair	fair
Red IFBB-CF	fair/good	good	60	poor	fair	good	fair/good	60	good	good
Golden Yellow IRK	fair/good	good	over 40	poor	poor	good increase yellow cast	fair/good	40	poor	fair
Green IB	fair/good	good	over 40	poor	poor	good increase blue cast	fair/good	40	poor	fair
Grey IBL-CF	fair/good	good	over 40	good	good	added yield	fair/good	30	good	good
Brown IBR	fair/good	good	over 60	good	good	sl. added yield	fair/good	over 60	good	good
Olive Green IB-CF	fair/good	good	over 60	poor	poor	added yield (yel)	fair/good	over 60	fair	fair
Blue IBC	fair/good	good	over 60	poor	fair	good	fair/good	over 60	fair	good

with leuco esters. 3% p-phenylphenol was applied with the dye. No increase in yield or improved fastness was noted.

EFFECT OF PRETREATMENTS——A reduced vat trial was made. Nylon was included in the test for comparison.

Type of dye: Vat color (2 oz/gal Jade Green)
Pretreatment: 2% Salicylic acid, pad and dry.
Dyeing Method: Dyed reduced in the molten-metal machine at 208° F.
Assistant: None.
Aftertreatment: Heat treatment, 55 secs at 350° F.

Results:

	Before Heat Treatment: Color Yield	Wash Fastness	Light Test	Crock Fastness	After Heat Treatment: Color Yield	Wash Fastness	Light Test	Crock Fastness
Dacron Filament	poor	good	good	—	fair	fair/good	good	—
Nylon Filament	good Blue cast	fair/good	good good	— —	good	good	good	—

It was hoped that pretreatment with salicylic acid, which is known to be effective on nylon, would be effective on Dacron. The result was negative although some improvement was shown with heat treatment.

EFFECT OF STEAMING TIME ON VAT DYES——Trials were made to determine the effect of steaming time on vat dyes applied as pigment, sodium leuco, and acid leuco. An attempt was made to carry out such a survey with two vat dyes, Ciba Blue 2B and Blue BCS.

Procedure: Each vat dye was padded on cloth swatches at 2 oz/gal in pigment form, as an acid leuco and as the sodium leuco. Portions of the padded samples were then dried, others were steamed 15 seconds, and a third set was steamed 15 minutes. All samples were soaped 5 minutes at 160°F and rinsed before testing.

Results: The pigment form of both Blue BCS and Blue 2B showed poor initial depth, poor washfastness, and little or no dyeing. The sodium leuco form was not much better in the case of the 2B type, but the BCS leuco definitely dyed after a 15-minute steaming. The acid-leuco dyes gave the greatest depth of shade (and worst crocking) of all three forms of these two dyestuffs. Because a prolonged steaming time would make a continuous process impractical and the results were not promising, no further work was carried out along this line.

DACRON SAMPLES INSERTED IN PLANT RUNS

Pad-Steam. Approximately a 12 x 12" swatch of Dacron staple was sewn into a piece of 80 x 80 sheeting and run through a steam range. The operation was as follows: pigment pad, run wet into chemical pad, steam 12 secs, rinse, oxidize and scour in a 5-box range. The dye formula employed in this run was as follows:

	oz/gal
Khaki 2G	10.00
Brown G	0.80
Orange 3G	0.19

Dacron took up reasonable quantities of dye in this trial even though it did not approach cotton in depth. Light and washfastness were excellent on the samples, and the fastness to crocking after the wash test was passable and much better than would be obtained in a laboratory dyeing.

Williams Unit. A 12" x 12" swatch of Dacron fabric was sewed into a length of 80 x 80 cotton print cloth which was dyed a purple shade in a regular run on the Williams range. The dyes employed were as follows:

	oz/gal
Violet BN	1.10
Olive R	0.19
Red FBB	0.07

The fabric was padded with pigment, run wet into two Williams units containing caustic soda and hydrosulfite, rinsed, oxidized with chrome and acetic acid, soaped, and rinsed.

The Dacron sample showed very little color pickup. After the wash test, the sample showed excellent crockfastness.

Leuco-Ester Dyes. Laboratory experiments had indicated the feasibility of applying leuco-ester dyes to synthetic fibers. Since the only drawback was crocking, it was desirable to conduct a plant run to see if crocking was less pronounced. Cotton and Orlon were used as with Dacron above.

The dye formula employed was as follows:

	oz/gal
Blue IBC	1.93
Red IFBB	0.13
Olive Green IB	0.05

The pad liquor also contained a wetting agent, soda ash, sodium nitrite, Glauber's salt and sodium thiosulfate. The first series was padded, developed in 7°Tw sulfuric acid, rinsed and soaped in a 7-box range according to the regular continuous process for cotton. The second series was padded, air-dried, and then developed and soaped in the regular way.

The usual excellent light and washfastness was obtained on the Dacron sample. As in the case of laboratory dyeings, crocking was not satisfactory, but it improved greatly after the wash test. The air-dried sample was somewhat greener in cast and had much better crocking fastness.

When these samples were tested with 1 oz/gal of caustic and hydrosulfite at 120°F, only the cotton failed to strip. This would indicate that surface pigmentation, rather than true dyeing, occurs with leuco-esters on Dacron.

REPEATED WASH TESTS ON VAT-ACID & LEUCO-ESTER DYEINGS——

Object: Previous work showed that vat and leuco-ester dyes had good wash and light-fastness on synthetic fabrics. Nevertheless, some doubt existed as to whether the fabrics were truly dyed or the color was deposited on the surface. The fact that many vat-dyed synthetics were quickly and completely stripped in caustic and hydro at 120°F supported the latter view. It was decided to dye up some samples with acid leucos and leuco esters and to subject them

to ten successive No. 3 (cotton) wash tests. Although this would not prove whether the fabrics were dyed, it would show whether these types of dyes were practical.

Procedure: Two vat colors, Yellow GK and Red FBB, were prepared as acid leucos with caustic and hydro and acetic acid at 120°F at a strength of 4 oz/gal. The fabrics were padded through this dispersion, steamed for 12 seconds, soaped at 140°F, rinsed and dried.

Two leuco esters, Olive Green IB and Red IFBB, were padded at 2 oz/gal with sodium nitrite, salt and sodium carbonate. After air-drying, the fabrics were padded through cold 7°Tw sulfuric acid, rinsed and soaped at 140°F.

Fiber: Dacron staple.

Tests: Each sample was tested for crocking and for resistance to stripping with caustic and hydro at 120°F for ½ hour (Launder-Ometer). Each sample was divided into ten 2" x 2" squares, which were subjected to successive No. 3 wash tests: 0.5% soap, 0.2% soda ash, 45 mins at 160°F. One sample was withdrawn after each wash cycle. Another crock test was run on the sample washed ten times.

Results: Dacron dyed up well. The resistance to ten washes was quite good even though most of the color was removed by surface stripping. From a comparison of Red FBB and Red IFBB (same molecular structure), it would be concluded that the leuco esters are slightly better than the acid leucos. The Yellow GK was least satisfactory of the four dyes from all standpoints.

After a heat treatment at 350°F for 1 minute, the Dacron samples showed much less stripping in caustic and hydro at 120°F. The results are shown in Table X.

EFFECT OF TEMPERATURE OF HEAT TREATMENT——Since heat treatment improved the dye fixation and yield in many cases, it was decided to determine the effect of different temperatures on dyeings and on the Dacron fiber.

The following formula was used:

Olive Green B	25 g
caustic soda	8 g
sodium hydrosulfite	12 g
sulfonated castor oil	5 g
water to make	800 ml

The dye was dispersed in water and the chemicals were added. The temperature was raised to 120°F. The dye was allowed to vat 15 minutes before padding.

The fabric was padded and dried at a low temperature. Cuttings were heat-treated at varying temperatures in a laboratory oven with forced circulation for 2 minutes. Each sample was cut in half, and one-half was surface-stripped. A measured sample of undyed cloth was given the same heat treatment and the shrinkage was observed. The results of color fixation and shrinkage are summarized in Table A.

TABLE A

EFFECT OF TEMPERATURE ON DYE ABSORPTION AND SHRINKAGE

Heat treatment 2 minutes

Fixation Temperature of	*Color of Sample After Treatment*	*Color of Sample After Surface Stripping*	*Undyed % Shrinkage Warp*	*Filling*
Original	dull olive	slight green stain	0	0
318	olive green	green tint	2.6	3.1
350	dull olive	light green	5.2	4.7
385	dull green	green	7.3	6.3
430	heavier and brighter dull green	full-depth green	12.5	12.5

It is obvious that with this dye there is no fixation by padding and drying at a low temperature, but as the temperature is increased, the color fixation is improved. At 430°F, the fixation is excellent. The shrinkage both in the warp and filling is progressive, indicating that at the point of maximum dye absorption, considerable softening or swelling is taking place, and the fiber has become plastic enough to absorb the dye.

EFFECT OF TIME OF HEAT TREATMENT——As the effect of temperature on dye absorption was well established, it was necessary now to establish the effect of time on heat treatment. In addition, previous work had shown that, whereas it is possible in many cases to get excellent wash and lightfastness and fair to good crocking fastness, the dyeings were not well penetrated as shown by the surface-stripping test developed in the course of this investigation. This led us to believe that partial dyeing was taking place in many instances, and that, if the best dyeing conditions were followed by a heat treatment to get the best dye fixation, a more efficient dyeing method could be found. Accordingly, the following different types of vat dyes were run by five different dyeing methods and heat-treated for varying times.

Dyes used were

Pink R and its leuco ester
Jade Green and its leuco ester
Brilliant Orange RK and its leuco ester
Brown BR and its leuco ester

The dyeing methods were as follows:

1) Pigment-pad. 4 oz/gal vat dye and 0.5% sulfonated castor oil padded at 120°F. Dried at low temperature.

2) Pad-reduced. 4 oz/gal vat dye, 1% caustic soda, 1.5% sodium hydrosulfite, and 1% sulfonated castor oil padded at 120°F. In the case of Pink R, reduction was carried out at 180°F; padding at 120°F. After padding, the cloth was dried at low temperature. In all cases the dye oxidized during drying.

3) Pad vat-acid. 4 oz/gal vat dye, 0.75% caustic soda, and 1% sodium hydrosulfite were vatted at 120°F (except for Pink R, which was vatted at 180°F); 2% Blancol, 2% acetic acid, and

TABLE X

SUCCESSIVE WASH TESTS

Indigosol Olive Green IB	*Dacron*	*Acrilan*	*Dynel*	*Orlon*
Depth	good	good	good	good
Strip Test	poor	poor	poor	poor
Resistance to 10 No 3 Washes	fair	good	good	good
Crocking	poor	poor	poor	poor
Crocking after 10 Washes	good	fair	fair	fair
Indigosol Red IFBB				
Depth	good	good	good	good
Strip Test	poor	poor	poor	poor
Resistance to 10 No 3 Washes	fair	good	good	fair
Crocking	poor	poor	poor	poor
Crocking after 10 Washes	poor	poor	poor	good
Carbanthrene Red FBBA				
Depth	good	good	good	good
Strip Test	poor	poor	poor	poor
Resistance to 10 No 3 Washes	fair	fair	good	poor
Crocking	poor	poor	poor	poor
Crocking after 10 Washes	poor	poor	poor	poor
Ponsol Yellow AR				
Depth	fair	good	good	poor
Strip Test	poor	poor	poor	poor
Resistance to 10 No 3 Washes	poor	fair	fair	poor
Crocking	good	fair	fair	good
Crocking after 10 Washes	good	good	good	good

0.25% hydrosulfite were added. After padding at 110°F, the cloth was dried at low temperature. In all cases, after drying, the dye was oxidized.

4) Pad leuco ester. 2 oz/gal dye padded at 160°F and dried at low temperature. Only the green was developed.

5) Same as [4] except that 1% ammonium chloride and 0.25% ammonium hydroxide were added. After drying, the pink, green, and brown were partially developed; the orange was completely developed.

The dyeings were all cut into 5 parts after drying. One untreated piece was saved. The balance were heat-treated at 400°F for 1, 2, 3 and 5 minutes, followed by a surface stripping with 1% caustic and 1.5% hydro at 120°F until no more dye washed off. Crocking fastness was excellent. Washing and light tests were not carried out since previous work had shown that there was no wash-down or staining after a treatment such as this, and light tests already reported indicated that the fastness was equal to or better than the same dye on cotton. The results are tabulated below. The following comments should be made for each dye.

Pink R——The leuco ester with 1% ammonium chloride heat-treated for 1 minute showed by far the best results. Longer heating showed a progressive drop in brightness and depth. The leuco ester with no additions showed poor development after 1-minute heating, but after heating for two minutes showed excellent yield and brightness; further heating reduced the yield and brightness. Good yields were obtained by the vat-pigment, vat-reduced and vat-acid trials with maximum development at two minutes. There was little difference between the three mthods of application.

Jade Green——The vat-reduced dyeing showed the maximum color value and brightness at two minutes. The leuco esters with and without additions showed considerable migration. In all cases, the shade was much bluer than the corresponding shade on cotton.

Brilliant Orange RK——All developed shades were considerably yellower than the expected shade, the vat-acid showing the greatest yield and brightness.

Brown BR——The yield was only fair in most cases with the exception of the leuco ester with ammonium chloride.

These trials indicate that maximum fixation takes place after one to two minutes of heat treatment; in the case of the leuco ester of Pink R and Brown BR, with the addition of ammonium chloride; with Jade Green, the vat-reduced method; and with Brilliant Orange RK, the vat-acid method. In many instances the differences were too slight to record.

Additional vat colors were run by the pigment-pad and pad-reduced methods of application. The results are summarized as follows: In general the vat-reduced method is better. A notable exception is Orange RRT. Some dyes, such as Khaki 2G and Olive T, give very poor yields. A complete change of shade is noted with Ponsol Brilliant Red B. Violet RR is no longer sensitive to moisture (See Table B).

TABLE B

EFFECT OF TIME OF HEAT TREATMENT ON DEPTH OF SHADE

Vat colors (4 oz/gal), Leuco Esters (2 oz/gal) were padded, dried, heat-treated at 400°F, and surface-stripped.

Dye	*Heat Treatment Minutes*	*Vat Pigment*	*Reduced Vat*	*Vat Acid*	*Leuco Ester*	*Leuco Ester with 1% NH_4Cl*
Pink R	1	good	fair	fair	poor	excellent
Pr 109	2	good	good	good	very good	good
	3	good	good	good	good	good
	5	good	good	good	good	good
Jade Green	1	good (B, D)	excellent (B)	very good (B)	poor (B, M)	good (B, M)
CI 1101	2	good (B, D)	excellent (B)	very good (B)	fair	good (B, M)
	3	good (B, D)	excellent (B)	very good (B)	fair	good (B, M)
	5	good (B, D)	excellent (B)	very good (B)	good	good (B, M)
Brilliant Orange	1	good (Y, D)	good (Y)	good (Y)	poor (Y)	good (Y)
RK Pr 116	2	good (Y, D)	good (Y)	good (Y)	poor (Y)	good (Y)
	3	good (Y, D)	good (Y)	good (Y)	fair	good (Y)
	5	good (Y, D)	good (Y)	good (Y)	good	good (Y)
Brown BR	1	fair	poor (Y)	fair	poor	good
Pr 118	2	fair	poor (Y)	fair	poor	good
	3	fair	poor (Y)	fair	poor	good
	5	fair	poor (Y)	fair	poor	good
Olive GGL	1	poor (G)	good (G)			
	2	good	excellent			
Olive T	1	poor	poor			
	2	poor	fair			
Khaki 2G, Pr 122	1	poor	poor			
	2	poor	poor			
Olive Green B	1	poor	good			
Pr 293	2	poor	excellent			
Golden Orange RRT	1	excellent (Y)	good (Y)			
CI 1098	2	excellent (Y)	good (Y)			
	3	excellent (Y)	good (Y)			
	5	excellent (Y)	good (Y)			
Direct Black 3G	2	poor	fair			
Ciba Gray	2	poor	fair			
Leucosol Black	2	good	good			
Brown RRD	1	fair	good			
	2	fair	good			
Yellow G	1	poor	fair			
CI 1118	2	poor	fair			
Violet RR	1	fair (R)	good (R)			
CI 1104	2	fair (R)	good (R)			
Brilliant Red B	1	poor	fair (O)			
	2	poor	fair (O)			
Ciba Blue 2B	1	fair	fair			
CI 1184	2	fair	fair			
Blue BCS	1	poor	poor			
CI 1113	2	poor	poor			

The letters in parentheses indicate the following: B—bluer, D—duller, G—greener, R—redder, Y—yellower, M—migration, and O—orange.

EFFECT OF HEAT TREATMENT ON FLUORESCENCE OF VAT-DYED DACRON——The samples both before and after heat treatment were examined for change in shade and evidence of fluorescence under ultraviolet light.

In the course of this investigation, an interesting phenomenon was observed. Many extreme color changes were noted under ultraviolet light after heat treatment. It was felt that possibly the heat treatment may be modifying the structure of the fiber or dye or both. Therefore, these observations may be indicative of what is occurring.

No consistent trends were found in this study. The fluorescent effect varied with the dyestuffs. Usually Dacron showed the greatest change of depth and shade on heat treatment compared with the other synthetics. Further investigation of such phenomena might contribute valuable information on the actual effect of heat treatment.

The observations are shown in Tables XI and XII. These tables might be of value for fiber identification. In addition, the fluorescent effect of Dacron might be developed into a useful method for determining the required amount of heat treatment.

TABLE XI

EFFECT OF HEAT SETTING ON FLUORESCENCE IN UV LIGHT OF SYNTHETIC FIBERS DYED WITH LEUCOESTERS

Dyestuff	*Fiber*	*Change in Shade*	*Improved Crocking*	*Fluorescence Before*	*Fluorescence After*	*Effect of Heat Setting Color in UV Light Before*	*Effect of Heat Setting Color in UV Light After*
Brilliant Orange IRK	Nylon	yes	yes	no	no	brown	salmon
	Dacron	yes	yes	yes	yes	blue	deepens
	Orlon	no	yes	no	no	lavender	salmon
	Acrilan	no	no	no	no	orange	same
	Dynel	no	no	no	no	pink	same
Golden Orange IRR	Nylon	yes	yes	no	no	brown	salmon
	Dacron	yes	yes	yes	no	blue	pink
	Orlon	yes	yes	no	no	pink	orange
	Acrilan	no	no	no	no	orange	same
	Dynel	no	no	no	no	pink	same
Golden Yellow IRK	Nylon	yes	yes	no	yes	olive	yellow
	Dacron	yes	yes	yes	yes	blue	orange
	Orlon	yes	yes	no	no	tan	orange
	Acrilan	no	no	no	no	orange	same
	Dynel	no	no	no	no	tan	same
Grey IBL	Nylon	yes	yes	no	no	blue	lemon
	Dacron	yes	yes	yes	no	blue	purple
	Orlon	yes	yes	no	no	blue	lemon
	Acrilan	yes	no	no	no	grey	same
	Dynel	no	no	no	no	grey	same
Red IFBB	Nylon	yes	yes	no	yes	maroon	brilliant orange
	Dacron	yes	no	yes	yes	blue	brilliant pink
	Orlon	no	no	no	no	blue	dull-pink
	Acrilan	no	no	no	no	pink	same
	Dynel	no	no	no	no	pink	same
Purple AR	Nylon	yes	yes	no	yes	pink	brilliant red
	Dacron	yes	yes	no	yes	blue	brilliant orange
	Orlon	yes	no	no	no	blue	dull pink
	Acrilan	no	no	no	no	blue	same
	Dynel	no	no	no	no	pink	same
Blue IBC	Nylon	yes	no	no	no	blue	grey
	Dacron	no	no	yes	yes	blue	pink
	Orlon	no	no	no	no	blue	lemon
	Acrilan	no	no	no	no	blue	lemon
	Dynel	no	no	no	no	blue	same
Brown IBR	Nylon	yes	yes	no	no	blue	brown
	Dacron	yes	yes	no	no	blue	pink
	Orlon	no	yes	no	no	brown	tan
	Acrilan	no	no	no	no	brown	brown
	Dynel	no	yes	no	no	brown	brown
Olive Green IB	Nylon	yes	no	no	no	grey	olive
	Dacron	yes	yes	yes	no	blue	pink
	Orlon	no	no	no	no	grey	lemon
	Acrilan	no	no	no	no	yellow	same
	Dynel	no	no	no	no	grey	grey
Green IBA	Nylon	yes	yes	no	no	dark blue	green
	Dacron	yes	yes	yes	no	blue	pink
	Orlon	yes	no	no	no	green	lightens
	Acrilan	no	no	no	no	green	same
	Dynel	no	yes	no	no	green	same
None	Nylon	yes	—	no	no	dark-grey	light-grey
	Dacron	no	—	yes	yes	blue	reddish-blue
	Orlon	yes	—	yes	yes	white	cream
	Acrilan	yes	—	yes	no	cream	yellow
	Dynel	no	—	yes	yes	pale-yellow	same

SPECTROPHOTOMETRIC MEASUREMENTS——An attempt was made to measure spectrophotometrically the increased depth which was apparent in many instances before and after heat treatment. The following dyes and their leuco esters were applied:

Jade Green (CI 1101)
Brilliant Orange RK (Pr 116)
Brown BR (Pr 118)
Pink R (Pr 109)

The dyes were padded at a concentration of 4 oz/gal as pigments, vat acids and leuco esters, dried and heat-set at 425°F for one minute.

It was impractical to predict visual strength and shade of the Dacron from spectrophotometric data because the difference between predicted and actual was so great. This phenomenon is unique for Dacron and deserves further study, which is beyond the scope of this paper.

PLANT TRIALS

VAT COLORS ON DACRON——

Leuco Ester of Pink R. Since the leuco ester of Pink R appeared to give excellent results in laboratory trials, an attempt was made to run the simplest commercial dyeing possible with outstanding yield and brightness consistent with excellent fastness to washing and crocking. Accordingly, a continuous dyeing was made on the following equipment:

Continuous range equipped with padder.
High-velocity air dryer operating at 280°F. (Andrews and Goodrich).

Gas-fired curing box for heat-treating.

The range was equipped with suitable controls so that the drying and heat treatment could be run separately or in range. Since only twenty yards of material was available, it was decided to pad and dry, then run into the curing box. If more material had been available the operation would have been run continuously as was the plant practice.

Material: 30" Spun Dacron.

Dyeing Formula: 2 oz/gal Indigosol Pink IR (the leuco ester of Vat Pink R) with 1 oz/gal of ammonium chloride and 0.25 oz/gal ammonia water. Padded at 140°F at 50 yds/min. Heat-treated 1.5 mins at 400°F.

Padding and drying ran satisfactorily with no color development after drying. It had been anticipated that trouble might be encountered during the heat treatment since the softening of the fibers and cloth shrinkage might cause creases. A half-yard cutting ran satisfactorily and the piece was processed. It was amazing to the operators and observers to see the colorless piece of cloth go into the machine and come out a heavy, bright, fluorescent red. The dyeing looked satisfactory and no trouble was encountered. The cotton leader was a dull light pink.

Laboratory tests indicated that no increase in color value or reduction in crocking could be obtained by additional heat treatment.

Finishing procedure: Beaker treatment with the surface stripping agents indicated that, to strip continuously, high temperatures would be necessary. Accordingly, the dyed material was run through a six-box open washer at 100 yds/min with the first two boxes containing 1% caustic soda and 1.5% sodium hydrosulfite. Crocking was still bad, and the material was run a second time with no better results. It was felt that in the short time of immersion and the difficulty of maintaining reducing conditions, a dye as difficult to reduce as indigoid pink might better be surface-stripped by running through a continuous pad-steam range equipped with Williams unit. Therefore, the cloth was run through such a range at 75 yds/min with 4 oz/gal of caustic soda and 4 oz/gal hydrosulfite in the pad at 90°F, steamed 10 seconds, then run through one Williams unit with detergent at 210°F, followed by two washes and drying. The results were excellent, as shown by wash tests and the absence of crocking.

VAT APPLICATION OF JADE GREEN BY VAT PIGMENT, VAT ACID AND PAD REDUCED METHODS——

Laboratory results indicated that Jade Green applied by the pad reduced method, followed by a heat treatment, produced greater depth of shade and brightness than by the vat pigment and vat acid methods of application. Accordingly, plant trials were

made to check the laboratory results.

Vat-Pigment Method. Jade Green paste was made up to a concentration of 4 ounces per gallon with water at 120°F containing 0.5 ounce per gallon Blancol as a dispersing agent. The vat paste was strained into the water and dispersing agent. The vat-pigment dispersion was run into two pad boxes. From the padders, the fabric went to a hot-air predrier having an air temperature of 270-280°F and then onto an enclosed 90-foot clip tenter frame running at a temperature of 260-270°F. On leaving the frame the dried pigmented goods entered an Andrews and Goodrich hot-air gas-fired curing unit where they were subjected to a temperature of 450°F for 50 seconds. The cloth during these continuous operations was running 38 yards per minute.

It was found by laboratory testing that the 50-second heat treatment at 450°F was insufficient, so the fabric was run into the curing unit a second time for another heat treatment of 450° for 50 seconds for a total heat-treating time at 450°F of one minute 40 seconds. After heat treatment the fabric was run through a pad-steam unit with only a 3-bowl chemical pad for a reducing and stripping unit. The chemicals used in the pad were caustic soda and sodium hydrosulfite at a concentration of 4 ounces per gallon of each. The pad-box temperature was 90°F. After the fabric was padded with caustic and hydro, it entered the steamer where it was steamed at 215°F for 10 seconds. On leaving the steamer it entered a Williams unit containing 0.5 lb Nonic 218, a nonionic detergent, and 7.5 pounds of sodium bicarbonate. The temperature in the Williams unit was 210-212°F. On leaving the Williams unit the fabric ran through two open-width wash boxes of water at 180°F. The speed of these operations was 80 yards per minute. The next operation was frame drying and batching, followed by rolling on tubes.

Vat-Acid Method. 7.7 pounds of Jade Green Double Paste was strained into 13.5 gallons of water at 130°F containing 1.5 pounds Blancol. Six pints of caustic soda, 52°Tw, was added and 2 pounds sodium hydrosulfite was sifted in. The dye was allowed to reduce 10 minutes, then was cooled down to 90°F with water, 1 gallon of acetic acid, 56%, was added, and the volume was adjusted to give a dye concentration of 4 ounces per gallon. The dye was then padded as described above for the vat-pigment method.

Pad-Reduced Method. 4 ounces per gallon Jade Green Double Paste was reduced with a concentration of 2 ounces per gallon caustic and 2 ounces per gallon hydrosulfite at 130°F. The dye-bath, after reducing 10 minutes, was padded as described above for the vat-pigment method. The plant runs con-

TABLE XII

EFFECT OF HEAT SETTING ON FLUORESCENCE OF VAT-DYED SYNTHETIC FIBERS IN ULTRAVIOLET LIGHT

Dyestuff	*Fiber*	*Change in Shade*	*Fluorescence*		*Effect of Heat Setting Color in UV Light*	
			Before	*After*	*Before*	*After*
Olive Green B	Orlon	no	no	yes	grey	yellow
	Nylon	no	no	no	brown	olive
	Dacron	no	no	no	blue	darkens
	Acrilan	no	yes	yes	bright-cream	duller-greener
Jade Green	Orlon	yes	no	yes	blue	light yellow
	Nylon	no	no	no	green	light green
	Dacron	yes	no	no	blue	pinker
	Acrilan	yes	yes	yes	green	darkens
Yellow GC	Orlon	no	yes	yes	yellow	same
	Nylon	no	no	no	brown	green yellow
	Dacron	no	no	no	pink	same
	Acrilan	no	yes	yes	brilliant-yellow	darker
Yellow GK	Orlon	no	no	yes	orange	yellow
	Nylon	no	no	no	dark orange	light orange
	Dacron	no	no	no	red orange	dulls
	Acrilan	no	yes	yes	brilliant-yellow	dulls
Brilliant Orange RK	Orlon	no	no	yes	pink	salmon
	Nylon	yes	no	no	rust	lightens
	Dacron	yes	no	no	blue	red, blue
	Acrilan	no	yes	yes	bright-pink	dulls
Golden Orange 3G	Orlon	no	no	yes	brown	cream
	Nylon	no	no	no	brown	cream
	Dacron	no	no	no	blue	same
	Acrilan	no	yes	yes	bright-cream	dulls
Golden Orange RRT	Orlon	no	no	yes	rose	orange
	Nylon	no	no	no	brown	lightens
	Dacron	yes	no	no	blue	orange
	Acrilan	no	yes	no	bright-orange	darkens
Red RK	Orlon	yes	yes	yes	pink	pale orange
	Nylon	no	no	no	rust	lightens
	Dacron	no	no	no	blue	darkens
	Acrilan	yes	yes	no	bright-salmon	yellow-darker
Red FBB	Orlon	yes	no	yes	purple	salmon
	Nylon	no	yes	no	orange	brighter
	Dacron	no	no	yes	pink	bright-orange
	Acrilan	no	no	no	pink	duller
Pink R	Orlon	yes	no	no	purple	duller
	Nylon	no	yes	yes	brilliant-orange	same
	Dacron	no	no	yes	pink	brilliant-orange
	Acrilan	no	no	no	pink	sli duller
Blue BCS	Orlon	yes	yes	no	blue	cream
	Nylon	no	no	no	purple	green, blue
	Dacron	yes	no	no	blue	same
	Acrilan	no	yes	no	light blue	duller, greener
Ciba Blue 2B	Orlon	yes	no	yes	blue	cream
	Nylon	yes	no	no	purple	light cream
	Dacron	yes	no	no	blue	same
	Acrilan	yes	yes	no	light blue	duller green
Midland Vat Blue R	Orlon	yes	no	no	blue	grey
	Nylon	yes	no	no	purple	light yellow
	Dacron	no	no	no	blue	same
	Acrilan	no	no	no	blue	duller green
Hydron Blue R	Orlon	yes	no	no	blue	lightens
	Nylon	no	no	no	purple	bluish purple
	Dacron	no	no	no	blue	same
	Acrilan	no	no	no	blue	duller
Brilliant Violet 3B	Orlon	yes	no	no	blue	salmon
	Nylon	yes	no	yes	maroon	bright pink
	Dacron	no	no	yes	blue	bright pink
	Acrilan	no	yes	no	bluish pink	duller
Violet BN	Orlon	yes	no	yes	blue	cream
	Nylon	yes	no	no	purple	pink
	Dacron	no	no	no	blue	same
	Acrilan	yes	yes	no	bright-white	yellow
Khaki 2G	Orlon	no	no	no	blue	cream
	Nylon	no	no	no	brown	light brown
	Dacron	no	no	no	blue	pinker
	Acrilan	no	no	no	tan	duller
Olive R	Orlon	yes	no	no	blue	cream
	Nylon	no	no	no	brown	lighten
	Dacron	no	no	no	blue	same
	Acrilan	yes	no	no	tan	duller
Brown G	Orlon	no	no	no	grey	cream
	Nylon	no	no	no	brown	lighten
	Dacron	no	no	no	blue	same
	Acrilan	no	no	no	tan	duller
		(Very similar to Olive R & Brown AG)				
Brown AG	Orlon	yes	no	no	blue	cream
	Nylon	no	no	no	brown	lighten
	Dacron	no	no	no	blue	pinker
	Acrilan	no	no	no	tan	duller
Direct Black 3G	Orlon	yes	no	no	blue	
	Nylon	no	no	no	brown	rust
	Dacron	no	no	no	blue	pinker
	Acrilan	yes	no	no	grey	yellow

* Does not include slight darkening or yellowing caused by heat setting.

firmed the laboratory result that the depth of shade and brightness obtained by the pad-reduced method were excellent.

The vat-acid method produced dyeings of very good depth and brightness. The vat-pigment method in comparison with the pad-reduced and vat-acid methods was fair in depth and dull in shade.

The shade obtained by the pad-reduced method was considerably bluer than the conventional shade produced on cotton. It was observed that the shade before heat treatment did not show the customary bluish cast. The dyeings possessed poor crock fastness after heat treatment and before surface stripping. After surface stripping they possessed excellent fastness to crocking, washing, and light.

It was interesting to note that the high temperature of heat treatment had little effect on the tensile strength as shown by the following data:

	TENSILE STRENGTH Average Pounds	
	Warp	*Filling*
Prepared Goods	181	141
Vat-Pigment	206	153
Vat-Acid	206	145
Reduced Vat	186	139
Leuco Ester	202	146

DISCUSSION OF RESULTS——It has been observed that vat dyes in aqueous solutions are not absorbed by Dacron in the same manner as by cotton. This must be due to the low water absorption or hydrophobic character of the Dacron fiber. It is true that in many instances a continuous method of application of vat dyes in solution will result in dyeings that are relatively fast to washing; this has been proved by the fact that after ten washings the depth of dyeing is still satisfactory. However, the crock fastness of most aqueous dyeings has been poor and crocking still persists after ten #3 AATCC cotton-washing tests.

When aqueous dyeings are subjected to surface stripping tests, removed of most of the dye indicates that there is very little dye penetration into the Dacron fiber from an aqueous solution. Also, cross-sectional photomicrographs of aqueous vat dyeings show no dye penetration into the fibers but a concentration of dye on the surface of each fiber. Since the wash fastness in many cases is satisfactory there must be a strong surface attachment between the dye and the Dacron fibers. This characteristic of the Dacron fiber varies according to the individual dye and the method of its application. It must be noted, however, that in no instances was it possible to obtain penetrated vat dyeings from an aqueous medium by any of the conventional methods of continuous application.

Shrinkage data indicated that the Dacron fiber is affected by a temperature of 320°F. As the temperature is increased, the shrinkage also increases, and at 430°F it amounts to 12.5%.

It has been found that vat dyes which have been applied from an aqueous solution and dried diffuse into the fibers when heat treated *(30)*. The degree of penetration depends on the temperature and time of heat treatment; also, on the individual chemical characteristics of the dyes and the physical state of the dye particles on the surface of the Dacron fibers.

It would have been difficult to study the diffusion of the vat dyes into Dacron without the discovery and development of the surface stripping test. Vat dyes on the surface of Dacron fibers are readily dissolved at low temperatures by solutions of caustic soda and sodium hydrosulfite without affecting the dye that has penetrated into the fibers. It has been demonstrated that, after the surface dye has been removed, there is no further discoloring of a fresh stripping solution, even when the dyeing is left in the solution overnight. Further, in most instances the dyed fibers after the strip do not show the expected leuco color change when treated with the reducing solution at the temperature at which the test is carried out. Presumably, if the reducing chemicals actually penetrated the fiber, a color change of dyed fibers would be observed. This surface stripping test is a valuable tool for rapidly measuring the degree of dye penetration into Dacron fibers. It is faster and more convenient than the use of the microscope.

The temperature of the heat treatment is an important factor in the diffusion of vat dyes into Dacron fibers. Very little diffusion takes place below 400°F. Some diffusion takes place at 320°F, but this could be classed as slight staining. At temperatures above 400°F there is considerable diffusion. However, careful controls are necessary since the sticking point of Dacron is 460°F and the melting point is 480°F.

The optimum time of heat treatment was found to be between one and two minutes at 430°F in a forced-air oven, and in plant trials in a gas-fired curing box. More rapid heat-transferring equipment would no doubt reduce the time. The construction of the fabric should also be taken into account. Shorter time did not produce maximum diffusion, and longer time tended to reduce the brightness of the dyeings. In the case of the leuco esters, longer time of heat treatment showed improvement in one or two cases but possibly this was due to the greater stability of these leuco esters. When an acid salt was incorporated into the dye formula, more rapid development took place, accompanied by diffusion into the fibers.

On heat treatment the degree of diffusion of the dye into the fibers varies with the individual dyestuffs. For example, Jade Green and Pink R types diffuse readily, whereas Khaki 2G and Olive T types show relatively poor absorption. The molecular weights of these dyes are as follows:

Dye Type	*Molecular Weight*
Vat Pink R	393
Vat Jade Green	516
Vat Olive T	670
Vat Khaki 2G	1084

Therefore, it might be assumed that the large molecular size of Khaki 2G may prevent penetration into the fibers. However, before any theory is evolved, additional data on the diffusion characteristics of the various types of vat dyes under different conditions of time and temperature should be made available.

After a treatment with heat, the shade of the dyeings in many instances was quite different from the shade on cotton. For example, the Brilliant Orange RK and Golden Orange RRT types produced a yellow rather than the characteristic orange; the Brilliant Red B type produced an orange; the Brilliant Violet 4R type produced a bluish red; and the Jade Green produced a bright greenish blue.

The results of the dye absorption after heat treatment of the same vat dyes applied by five different methods were recorded. A study of these data indicates that the condition of the dye particles (which is believed to be connected with their pigment-particle size) attached to the surface of the Dacron fibers before heat treatment is an important factor in dye absorption. Some of the vat dyes, when applied at the same concentration by different methods before heat treatment, showed a striking difference in depth. Greater depth is usually associated with smaller dye-particle size. Therefore, it is readily understood why the selection of the proper method of dye application will result in more dye absorption on heat treatment. The method of dye application will thus have important practical significance in commercial vat dyeings.

As previously described, Jade Green was applied by three different methods in the plant to check the practical aspects of this discovery. The concentration of the dye and the aftertreatment were the same in each instance. Examination of the three finished dyeings showed marked differences: a fair yield of a dull shade in the case of the vat-pigment application, a very good yield of good brightness in the case of the vat-acid application, and an excellent yield of good brightness in the case of the reduced-vat application. The vat-pigment application would have little practical value compared with the vat-acid or reduced method with this dye.

Previous investigators *(30)* recommend a vat-pigment application followed by a heat treatment and soaping. In the plant applications, however, it was not possible to remove the surplus dye by soaping, and the dyeings crocked badly. The discovery of the surface stripping test in the laboratory experimental work indicated that crocking could be entirely eliminated by this means. Accordingly,

the method of surface stripping was adapted for plant application. The attachment of dye particles to the surface of Dacron fibers is very strong, and, in our opinion, surplus dye cannot be removed completely by a soaping operation.

The plant dyeing with the leuco ester Pink IR is interesting in that no chemical oxidation was employed to develop this quite stable leuco ester. A more complete study might evolve additional simple formulation changes whereby the leuco esters of many other vat dyes could be applied from solution, dried and developed by a heat treatment, surface-stripped and soaped to obtain satisfactory results.

Also, an interesting observation is the change of shade and intensity of fluorescence of dyeings when examined under ultraviolet light before and after heat treatment. The data from spectrophotometric analysis indicate a considerable difference in shade before and after heat treatment. A careful study of the optical and chemical changes taking place when different types of vat dyes diffuse into Dacron fibers might be a fruitful field of research into the mechanism of the dyeing of this fiber. This is beyond the scope of this paper.

CONCLUSIONS——1) The surface stripping test was developed to show the degree of vat-dye penetration into Dacron fibers. This test method is a valuable laboratory aid for determining the degree of dye penetration and is more rapid than microscope techniques.

2) Many aqueous dyeings of vat dyes on Dacron fibers were made by continuous processes, but these dyeings, without subsequent heat treatment, did not exhibit penetration of the dye particles into the fiber.

3) The employment of pretreatments and the use of carriers or swelling agents was found to make no improvement in continuous dye application.

4) It was discovered that the physical state of the dye particles attached to the surface of the fibers made a tremendous difference in the degree of diffusion into the fibers and the brightness of the resultant dyeings.

5) The optimum time and temperature of the heat treatment required to diffuse dye particles into the fiber was found to be between one and two minutes at 430°F.

6) It was observed that, after the heat treatment where diffusion of dye into the fibers occurred, there was considerable shade change in the case of many vat dyes. An interesting observation was made that under ultraviolet light many extreme color changes and fluorescent effects were found after heat treatment. Similar changes have been found when the depth of dyeing was measured spectrophotometrically. No theory of the mechanism of these changes could be evolved with the limited data available.

7) On heat treatment without the use of chemical oxidizing agents many leuco esters of vat dyes develop and penetrate into the fibers. This is an interesting discovery and has practical significance since it makes a simple leuco ester application method possible.

8) Continuous plant dyeings were made on Dacron fabric with vat colors by our original methods of application and aftertreatment. These dyeings showed excellent fastness to light and washing and no crocking, wet or dry. A previously described method of dyeing was carried out under identical conditions, and, by comparison, was found to be less satisfactory.

9) A simple aftertreatment with important commercial possibilities was developed which eliminated any tendency of vat dyes to crock.

VAT DYES ON ACRYLIC FIBERS

As mentioned previously, treatment with acid, acetate and premetallized dyes gave poor fastness on Acrilan, Dynel, and Orlon. Accordingly, we investigated the application of vat dyes and their leuco esters because of their superior properties. Our initial laboratory work on vat dyeing acrylic fibers was carried out by conventional methods. These

TABLE XIII

COMPARISON OF JADE GREEN, BRILL ORANGE RK, AND BROWN BR TYPES BY VAT-PIGMENT, VAT-ACID & LEUCO-ESTER METHODS

Dye & Method		*Orlon*	*Acrilan*	*Dynel*
Jade Green Pad pigment, dry, heat treat	Strip Test	poor	poor	poor
	Wash Test	poor	poor	poor
	Spectro (A) (B) Strength, % After H.T.	102 sli dull	110 sli yellow	100 yellower
Jade Green Pad vat acid, dry, heat treat	Strip Test	poor	poor	poor
	Wash Test	fair	poor	poor
	Spectro Strength, % After H.T.	122 similar	130 sli yellow	123 similar
Jade Green Pad pigment, dry, reduce, steam 15 seconds, wash, heat-treat	Strip Test	good	good	good
	Wash Test	fair to good	fair to good	good
Jade Green Pad leuco ester, develop with phosphoric acid, steam 12 seconds, rinse, dry, heat-treat	Strip Test	good	good	good
	Wash Test	fair to good	fair to good	good
	Spectro Strength, % After H. T.	90 sli yellow	111 sli bright	104 similar
Brill Orange RK Type Pad pigment, dry, heat-treat	Strip Test	poor	poor	poor
	Wash Test	poor	poor	poor
	Spectro Strength, % After H. T.	100 similar	115 sli dull	105 similar
Brill Orange RK Type Pad vat acid, dry, heat-treat	Strip Test	poor	poor	poor
	Wash Test	poor	poor	poor
	Spectro Strength, % After H.T.	100 similar	100 similar	109 sli brighter
Brill Orange RK Type Pad pigment, dry, reduce, steam 15 seconds, wash, dry, heat-treat	Strip Test	fair	fair	fair
	Wash Test	fair to good	good	fair
Brill Orange RK Type Pad leuco ester, develop with phosphoric acid, steam 12 seconds, rinse, dry, heat-treat	Strip Test	fair	fair	fair
	Wash Test	fair to good	good	fair
	Spectro Strength, % After H. T.	110 sli yellow	109 sli yellow	131 similar
Brown BR Type Pad pigment, dry, heat-treat	Strip Test	poor	poor	poor
	Wash Test	poor	poor	poor
	Spectro Strength, % After H. T.	93 similar	135 sli bright	132 similar
Brown BR Type Pad vat acid, dry, heat-treat	Strip Test	poor	poor	poor
	Wash Test	poor	poor	poor
	Spectro Strength, % After H. T.	110 similar	104 sli bright	123 sli brighter
Brown BR Type Pad pigment, dry, reduce, steam 15 seconds, wash, heat-treat	Strip	good	good	fair
	Wash Test	good	fair	good
Brown BR Type Pad leuco ester, dev phosphoric acid, steam 12 seconds, rinse, dry, heat-treat	Strip Test	good	good	fair
	Wash Test	good	fair	good
	Spectro Strength, % After H. T.	103 sli dull	123 sli bright	118 similar
Same as above except dry before developing	Strip Test	good	good	fair
	Wash Test	good	fair	good
	Spectro Strength, % After H. T.	100 sli red	115 similar	109 sli yellow

TABLE XIII (Concluded)

COMPARISON OF PINK R TYPE BY VAT-PIGMENT, VAT-ACID, AND LEUCO-ESTER METHODS

Dye & Method		*Orlon*	*Acrilan*	*Dynel*
Pink R Type	Strip Test	fair	good	good
Pad pigment, dry, heat-treat	Wash Test	poor	poor	poor
	Spectro Strength, % After H. T.	94 sli bright	100 yellow	105 yellow
Pink R Type	Strip Test	fair	fair	good
Pad vat-acid, dry, heat-treat	Wash Test	poor	poor	poor
	Spectro Strength, % After H. T.	113 sli bright	106 similar	110 sli yellow
Pink R Type	Strip Test	good	good	good
Pad pigment, dry, reduce, steam 15 seconds, wash, dry, heat-treat	Wash Test	fair to good	fair	good
Pink R	Strip Test	good	good	good
Pad leuco ester, develop with phosphoric acid, steam 12 seconds, rinse, dry, heat-treat	Wash Test	fair to good	fair	good
	Spectro Strength, % After H. T.	113 sli yellow	110 sli yellow	125 sli yellow
Same as above except develop with sulfuric acid	Strip Test	good	good	good
	Wash Test	fair to good	fair to good	good
	Spectro Strength, % After H. T.	103 sli yellow	150 sli yellow	109 sli yellow

(A) The polarizing effect of Orlon was very pronounced. All data on this fiber were obtained by measuring each sample twice. The second measurement was made after rotating the sample 90° around an axis parallel to the direction of the propagation of the light. The two measurementsc were averaged.
(B) It was difficult to predict visual strength and shade of the Dacron samples from spectrophotometric data. The difference between predicted and actual in some cases is very striking.

TABLE XIV

COMPARISON OF LEUCO ESTERS BY PADDING, DEVELOPING, STEAMING

Dye		Cotton	Nylon	Dacron	Orlon	Dynel	Acrilan
Brill Orange IRKL	Depth	good	good	fair	fair	good	excellent
	Wash	good	poor	poor	good	good	good
	Light	good	poor	good	excellent	excellent	good
	Crock	fair	poor	poor	poor	poor	poor
	S-crock	good	good	good	fair	good	poor
Gold Orange I2R	Depth	good	good	fair	good	good	good
	Wash	good	fair	fair	good	good	good
	Light	fair	fair	fair	fair	fair	fair
	Crock	fair	fair	fair	poor	poor	poor
	S-crock	fair	fair	fair	fair	fair	poor
Grey IBL	Depth	excellent	good	good	good	good	good
	Wash	excellent	poor	fair	fair	good	good
	Light	fair	poor	fair	fair	fair	fair
	Crock	good	fair	good	poor	fair	poor
	S-crock	good	good	good	good	fair	poor
Purple AR	Depth	excellent	excellent	good	good	excellent	excellent
	Wash	good	fair	good	fair	good	good
	Light	fair	poor	fair	good	good	good
	Crock	poor	good	good	poor	poor	poor
	S-crock	poor	good	good	poor	poor	poor
Green IBA	Depth	excellent	excellent	good	good	excellent	excellent
	Wash	good	poor	fair	good	good	good
	Light	good	good	good	good	good	good
	Crock	poor	fair	fair	poor	poor	poor
	S-crock	poor	fair	fair	poor	fair	poor
Blue IBC	Depth	excellent	excellent	good	good	good	good
	Wash	excellent	poor	good	good	good	good
	Light	excellent	good	good	excellent	good	good
	Crock	good	good	good	fair	good	fair
	S-crock	good	good	good	fair	fair	fair
Brown IBR	Depth	excellent	good	good	good	fair	good
	Wash	good	good	good	good	good	good
	Light	excellent	excellent	excellent	excellent	excellent	excellent
	Crock	poor	fair	fair	fair	fair	poor
	S-crock	fair	fair	fair	fair	fair	poor
Gold Yellow IRK	Depth	excellent	good	good	good	good	good
	Wash	good	good	good	good	good	good
	Light	fair	good	good	good	good	fair
	Crock	poor	poor	good	fair	fair	poor
	S-crock	fair	fair	good	fair	fair	poor
Olive Green IB	Depth	excellent	good	good	good	good	good
	Wash	good	good	fair	good	good	good
	Light	excellent	good	good	excellent	excellent	excellent
	Crock	poor	fair	fair	poor	fair	poor
	S-crock	poor	fair	fair	poor	fair	poor
Red IFBB	Depth	excellent	good	good	good	good	good
	Wash	excellent	poor	excellent	excellent	excellent	excellent
	Light	good	good	good	good	good	good
	Crock	poor	fair	good	fair	fair	poor
	S-crock	fair	fair	fair	fair	fair	poor

dyeings had poor crockfastness. We therefore considered the possibility of improving fixation by subsequent heat treatment. The yellowing of Orlon and Acrilan fibers above 350°F limited the extent to which we could apply to these fibers the method which was so successful on Dacron, and Dynel was not included in this group of experiments since it will not withstand heating above 235°F.

Some evidence was obtained in laboratory work that pretreatment of acrylic fibers with cuprous ions would improve depth of shade and fixation of the leuco esters of vat dyes.

APPLICATION BY VAT-ACID METHOD——Twenty vat dyes were tested as follows:

Each color was prepared as an acid leuco at a concentration of 4 oz/gal by reducing in caustic and hydro and then adding acetic acid. The fabrics were padded through this dispersion at 120°F, batched, repadded through caustic and hydro at 100°F and immediately steamed for 12 seconds. After steaming, the samples were rinsed in cold water, soaped 1 minute at 160°F and air-dried. Orlon, Acrilan and Dynel were treated simultaneously in this series. For comparison, cotton and Dacron were included. Each dyed sample was tested for washfastness (No. 3), lightfastness (20 and 40 hours in the Fade-Ometer) and fastness to crocking. The results are given in Table IX.

The fastness properties varied with each dye. In general, poor yields were obtained on filament fabrics, whereas yields on staple fabrics were roughly comparable with those on cotton. Lightfastness of the acrylics was equal or superior to cotton. Washfastness was usually inferior to cotton. Crockfastness was fair to poor in almost all cases.

APPLICATION OF LEUCO ESTERS——Similar tests were carried out with ten leuco esters. Each dye was made up at 2 oz/gal with sodium nitrite, salt and sodium carbonate and padded on the fabric with 2 dips and 2 nips at 160°F. The samples were air-dried, padded through 7°Tw sulfuric acid, rinsed, soaped 5 min at 120°F, rinsed and ironed dry. Brown IBR was used at 4 oz/gal. Urea was added to the bath with the Orange IRK and thiourea was added for Green IB and Blue IBC. The same tests were applied with addition of a crock test on samples which had previously been given the No. 3 wash test. Results are shown in Table XIV.

Fastness properties of the leuco ester dyeings were generally similar to those obtained by the vat-acid method. Lightfastness was good, washfastness fair to good and crockfastness fair to poor. Crock tests on the washed samples did not show any improvement.

After the discovery of the surface strip-

ping test described above in the work on Dacron, it was found that almost all samples of the acrylics which had been vat-dyed by conventional processes could be completely stripped by this test. It was concluded that only surface coloration had been achieved by the continuous vat-dyeing procedures.

ACRYLIC SAMPLES INSERTED IN PLANT TRIALS——

A) *Pad-steam.* Approximately 12" x 12" swatches of Orlon, Dynel and Acrilan were sewn into a piece of 80 x 80 sheeting and run through a steam range. The operation was as follows: pigment-pad, run wet into chemical pad, steam 12 seconds, rinse, oxidize and scour in a 5-box range. The dye formula employed in this run was as follows:

	oz/gal
Khaki 2G	10.00
Brown G	0.80
Golden Orange 3G	0.19

All the synthetics took up reasonable quantities of dye in this trial even though they did not approach cotton for depth. Light- and washfastness were excellent on all samples, and the crocking after the wash test was passable and much better than would be obtained in a laboratory dyeing.

Inasmuch as a run of a single color by the acid-leuco process was scheduled for the steamer, small samples of Dynel, Acrilan and Orlon were sewed into 80 x 80 print cloth and run through the unit. The dye used in this run was 5.82 oz/gal Flavone GC, and it was applied as an acid leuco. Pickup tests were made on the fabrics included in this trial with the results below:

	% Pickup
Cotton broadcloth	88
80 x 80 Print cloth	83
Orlon	45
Dynel	59
Acrilan	65

As synthetic fibers took up very little color in this trial, it must be concluded that this dye cannot be applied satisfactorily by the regular acid-leuco-steam process used for cotton.

B) *Williams Unit*. Several 12" x 12" swatches of synthetic-fiber fabrics were sewn into a length of 80 x 80 cotton print cloth and dyed a purple shade in a regular run on the Williams range. The dyes employed were as follows:

	oz/gal
Violet BN	1.10
Olive R	0.19
Red FBB	0.07

The fabrics were padded with pigment, run wet into two Williams units containing caustic and hydro, rinsed, oxidized with chrome and acetic acid, soaped and rinsed.

Acrilan, Dynel and Orlon produced a grey shade instead of the violet expected. After the wash test, all samples showed excellent crockfastness.

C) *Leuco Esters.* Laboratory experiments had indicated the feasibility of applying leuco ester dyes to synthetic fibers. Since the only drawback was crocking, it was desirable to conduct a plant run to see if crocking was less pronounced. Samples of each synthetic were sewn into a length of 80 x 80 print cloth before dyeing. A duplicate set was prepared to test the effect of drying before development.

The dye formula employed was as follows:

	oz/gal
Blue IBC	1.93
Red IFBB	0.13
Olive Green IB	0.05

The pad liquor contained wetting agent, soda ash, sodium nitrite, Glauber's salt and sodium hyposulfite. The first series was padded, developed in 7°Tw sulfuric acid, rinsed and soaped in a 7-box range in the regular continuous process as applied to cotton. The second series was padded, air dried, and then developed and soaped in the regular way. Acrilan, Orlon and Dynel were included in these trials.

The usual excellent light- and washfastness was obtained on these samples. As in the case of laboratory dyeings, crocking was not satisfactory but it improved greatly after the wash test. The air-dried samples were somewhat greener in cast and had much better crocking tests.

When these samples were tested with 1 oz/gal of caustic and hydro at 120°F, only the cotton failed to strip. This would indicate that surface pigmentation, rather than true dyeing, occurs with leuco esters on the synthetics.

EFFECT OF STEAMING TIME——As work progressed on continuous methods of coloring synthetic fibers with vat colors, it became evident that a comprehensive survey would be required to determine the best form in which to apply the dyes, optimum steaming periods, and also the best type of dye from the standpoint of chemical structure.

An attempt was made to carry out such a survey with two vat dyes, Blue 2B and Blue BCS, as well as their leuco-ester derivatives, Blue O4B and Blue IBC.

Each vat dye was padded on cloth swatches at 2 oz/gal in pigment form, as an acid leuco, and as the sodium leuco. Portions of the padded samples were then air-dried, others were steamed 15 seconds, and a third set was steamed 15 minutes. The air-dried samples with the acid-leuco dye required an oxidation in boiling peroxide to develop the true shade; other air-dried samples of the acid-leuco dye were heat-set 1 minute at 350°F. (235°F for Dynel), but in this case no oxidation was required. All samples were soaped 5 mins at 160°F and rinsed before testing. The staple fibers included in this series were Orlon, Dynel and Acrilan.

The leuco-ester dyes were applied by padding 2 oz/gal of color in a solution containing sodium nitrite and sodium carbonate. One set of samples was air-dried and developed in acid; another set was dyed, developed and heat-treated; while a third set was steamed 15 seconds and then developed. In all cases development was carried out in 7°Tw sulfuric acid at 120°F. All swatches were soaped 5 minutes at 160°F before testing.

Tests: Each dyed swatch in this series was tested for crocking, before and after washing, a No. 3 (cotton) wash test, and the surface stripping test.

Results, Orlon: Good shades were obtained with Blue BCS whether it was applied as a pigment, sodium leuco or acid leuco. Only in case of the sodium leuco steamed 15 mins did any dyeing occur, as evidenced by the surface stripping test. Blue 2B gave almost no color in the pigment form. The use of Blue 2B as an acid leuco resulted in good depth of shade, poor crocking and appreciable dyeing after 15 minutes of steaming. The sodium leuco showed only slight dyeing in 15 seconds of steaming but excellent dyeing after 15 minutes of steaming.

A definite improvement in shade resulted when Blue O4B was padded and steamed before drying and developing. Heat treatment produced a very green shade indicative of color destruction. A surface strip test, however, indicated very little dyeing. Blue IBC gave results very similar to Blue O4B and was somewhat more resistant to heat treatment.

Dynel. The acid-leuco form of both Blue 2B and Blue BCS gave deeper and truer shades on Dynel than either the pigment or sodium-leuco forms. The dye pigments did not result in appreciable dyeing as measured by the surface stripping test. The sodium leuco was not much better except that Blue BCS steamed 15 minutes showed some dyeing. The acid leuco of Blue 2B was definitely better than Blue BCS both for dyeing and washfastness. Strangely enough, the padded, air-dried, oxidized sample showed greatest depth of shade after the surface stripping test. The 15-minute steaming of Blue 2B acid leuco resulted in dyeing, whereas heat treatment at 250°F did not.

Both leuco-ester dyes gave good bright shades on Dynel; the washfastness was good and crocking was fair (much better than acid-leuco dyeings). Samples produced by the pad-develop-heat-treat process showed the deepest shade. No appreciable dyeing occurred for any of the samples, as indicated by the surface stripping test.

Acrilan. Almost no color was obtained on Acrilan with the pigment form of Blue 2B. Blue BCS pigment gave a blue shade (not very heavy), and 15-minute steaming showed

some dyeing. The sodium-leuco form was definitely better than the pigment form of both dyes. Blue 2B sodium leuco steamed 15 minutes showed excellent dyeing by the strip test. Blue BCS sodium leuco partially dyed this fiber in 15 minutes of steaming. The acid-leuco form gave good dark shades on Acrilan, which crocked badly and stripped readily in caustic and hydro.

The leuco-ester dyes gave good blue shades, which showed fair washfastness and crocked less than the acid-leuco dyeings. No true dyeing resulted, however, as shown by the strip test.

REPEATED WASH TESTS——It is possible to produce commercially satisfactory dyeings in light and medium shades with the steaming times of 12 to 30 seconds which are normally used. Apparently a high degree of surface fixation is obtained under these conditions. Within the limitations of depth of shade, good washfastness, lightfastness and crockfastness can be obtained. This is illustrated in Table X. Two vat dyes, Yellow AR and Red FBBA, were applied from the acid-leuco form at a concentration of 4 oz per gallon, reduced with caustic soda and sodium hydrosulfite, steamed 12 seconds, soaped at 140°F, and dried. Two leuco esters, Olive Green IB and Red IFBB, were padded at a concentration of 2 oz per gallon with sodium nitrite, salt and soda ash, dried, developed with 7°Tw sulfuric acid, rinsed, soaped at 140°F, and dried. Successive No. 3 wash tests on these fabrics showed remarkably good fastness even though poor fixation was indicated by the surface stripping test.

EFFECT OF HEAT TREATMENT——The effect of heat treatment on acrylic fibers was studied with four vat dyes: Jade Green, Brilliant Orange RK, Brown BR and Pink R. The four dyes were applied by four different methods as follows:

A) Vat pigments dispersed in water were padded, dried and then heat-treated.
B) Vat acids were prepared and padded, dried and heat-treated.
C) To apply the sodium-leuco form the vat pigment was padded, dried, reduced with caustic soda and sodium hydrosulfite, steamed for 15 seconds, washed, dried and heat treated.
D) The leuco-ester derivatives of the same dyes were padded with nitrite, developed with phosphoric acid, steamed 12 seconds, rinsed, dried and heat-treated.

The heat treatments were as follows:
Orlon and Acrilan: 1 minute at 350°F.
Dynel: 1 minute at 240°F.

Each dyeing was subjected to a No. 3 wash test and a surface stripping test to determine dye fixation. In addition, spectrophotometric measurements were used to evaluate the effect of heat treatment. The results are shown in Table XIII.

Heat treatment resulted in some fixation of the dyes, but the effect on the acrylic fibers was much less than on Dacron. In general, the pigment and vat-acid applications resulted in poor fastness to washing. The reduced pigment and leuco-ester dyeings showed much better wash fastness. The surface stripping test removed most of the color on the pigment and vat-acid dyeings. Less color removal occurred with leuco-ester and reduced pigment dyeings.

Acrilan and Orlon yellowed during the heat treatment. This proved to be a limitation for the heat treatment of these fibers. This fact, and the low softening point of Dynel, led to the conclusion that heat treatment of acrylic fibers is not practical.

SPECTROPHOTOMETRIC MEASUREMENTS——The spectrophotometric measurements of the heat-treated Orlon and Acrilan dyeings of the preceding paragraphs confirmed the visual observations that heat treatment produced a slight increase in depth of shade. The Orlon fabric showed a pronounced polarizing effect. It was necessary to make two measurements, the second at a 90° angle to the first. The two measurements were averaged. Acrilan and Dynel did not exhibit the polarizing effect.

THE EFFECT OF HEAT TREATMENT ON FLUORESCENCE——The marked fluorescence of Dacron fabrics after heat treatment prompted a study of this phenomenon on the acrylic fibers. The dyed samples obtained with vat acids and with leuco esters were examined under ultraviolet light before and after a heat treatment. The results are shown in Tables XI and XII. The acrylic fabrics did not exhibit the marked fluorescence found for Dacron. Some Acrilan dyeings were fluorescent before and after heat treatment, but no color development or change was evident after heat treatment.

CUPROUS IONS WITH LEUCO ESTERS——The effectiveness of cuprous ions in assisting the dyeing of acrylic fibers with acid and direct colors has been described earlier. This led to the belief that cuprous ions might also assist in dyeing acrylic fibers with leuco esters. Beaker dyeings on acrylic fibers with leuco esters and cuprous ions simultaneously did not show the desired effect. However, pad-steam application of cuprous ions followed by application of leuco esters did show considerable promise.

A series of experiments was carried out on spun-Orlon fabric to determine the possibilities of the pad-steam procedure. Fabric samples were padded with the following solutions and then steamed for 15 seconds and 30 seconds. One-half of each sample was dried after steaming, the other half was soaped, rinsed and then dried.

No.	% Copper Sulfate Crystals	% Sodium Sulfoxylate	% Acetic Acid
1	0	0	0
2	5	2.5	1
3	10	5	1
4	1	2.5	1

The pretreated swatches were next padded through a solution of 2 oz/gal of a leuco ester and steamed 15 secs, 30 secs, 5 mins, and 10 mins. The swatches were then rinsed in water at 120°F, oxidized in a solution of 2% sulfuric acid and 1% sodium nitrite, washed and dried. This procedure was followed for both Pink IR and Green IB. Furthermore, the experiments were repeated and 5% acetic acid, 56%, was added to the leuco-ester pad liquor.

In this series of experiments no consistent evidence was obtained that cuprous ions assisted in the dyeing of Orlon with leuco esters. The presence of acetic acid in the dye liquor reduced the variation in results. With acid present, Pink IR showed the greatest depth with 10 minutes of steaming, whereas the Green IB showed the best results after 15 seconds of steaming. In almost all cases the dyed swatches could be developed cold and most of the color could be removed by the surface stripping test.

A separate set of experiments was carried out employing all three acrylic fibers, Acrilan, Dynel and Orlon. Swatches of each fabric were pretreated with copper by padding with a solution of 10% copper sulfate, 4% Sulfoxite, 1% Duponol ME and 2% acetic acid. The swatches were then steamed 15 seconds, rinsed in cold water and air-dried.

Treated and untreated samples of each fiber were sewed together and dyed by padding at 2 oz/gal of dye. Solutions were made of four leuco esters containing sodium nitrite and sodium carbonate and 1 oz/gal of Sulfoxite C. One set of padded samples was steamed 15 seconds, while another set was steamed 5 minutes. The four colors employed were:

Green IB
Pink IR
Brill Orange IRK
Blue IBC

Dyed swatches were next treated with a solution of sodium nitrite and sulfuric acid to develop the final shade. It was found that some swatches would not develop unless the nitrite solution was heated to boiling. This was taken as evidence of penetration or true dyeing by the leuco ester. The developed swatches were rinsed, soaped for 5 minutes at 160°F, rinsed and pressed dry.

The results shown in Table XV indicate that cuprous ions were more effective for Pink IR and Green IB than for Blue IBC or Orange IRK. Among the fibers, the presence of cuprous ion showed the greatest effect on Acrilan, Dynel was next, and Orlon was the least affected. It may be concluded therefore, that the effectiveness of copper pretreatment varies with both the dye and

the fiber.

It was decided to conduct a small plant trial on the cuprous-ion/leuco-ester process as a follow up of the laboratory work. A 60-yard cut of spun Orlon and a smaller yardage of Acrilan were boiled off on a jig, loop-dried and steam-framed for dyeing. After small yardages of each fabric had been reserved for controls, they were treated with copper by padding twice with the solution that follows, steamed 30 seconds, rinsed cold in a Williams unit, loop-dried and short-framed.

Copper sulfate hydrate	10%
Sulfoxite C	4%
Acetic acid, 56%	2%

Dye was applied to 15 yards of copper-treated Orlon, 3 yards of untreated Orlon, 2 yards of treated Acrilan and 1 yard of untreated Acrilan. The fabrics were padded through a leuco-ester solution containing 2 oz/gal of Pink IR, 1 oz/gal Sulfoxite C, 1 oz/gal Tetranol and sufficient soda ash to give a pH of 10. The fabrics were padded 1 dip, 1 nip through the dye solution at 180°F, steamed 15 seconds, and rinsed through 5 boxes of cold water. Without drying, the fabrics were padded through 8 oz/gal of sodium nitrite and run into a multiple dip box containing sulfuric acid, 7°Tw, at a temperature of 180°F. A seven-box, open-width, soaping range followed the acid development. Although the cotton leaders were brought to full shade by the nitrite-acid development, the Orlon samples appeared somewhat dull and were rerun through the developing and soaping range. The untreated Orlon sample was a light shade of pink, the untreated Acrilan contained no color, whereas both of the copper-treated samples were a light brick color, which could not be developed to the expected shade of pink.

It was concluded from the unsatisfactory results of this trial that additional work would be required to define optimum conditions for cuprous-ion/leuco-ester dyeing. We believe that this process will eventually be very valuable for dyeing acrylic fibers. Therefore, the remaining copper-pretreated cloth was used for further laboratory experiments.

The wool method of dyeing was used in applying the leuco ester of Pink IR to both untreated and copper-pretreated Dynel, Acrilan and Orlon. The dyeing was carried on for 40 minutes at 190°F in the presence of formic and acetic acid, followed by development at 190°F with sodium bichromate, ammonium thiocyanate and sulfuric acid. Copper-pretreated samples of all three fibers showed greater depth of shade and good color fixation, as evidenced by wash and surface stripping tests.

This work demonstrated that cuprous-ion pretreatment makes it possible to dye the acrylic fibers with leuco esters of vat colors, and showed that the cuprous ion can be applied successfully by a continuous process.

TABLE XV

Dye		*Test*	*Orlon* 15 sec	*Orlon* 5 min	*Dynel* 15 sec	*Dynel* 5 min	*Acrilan* 15 sec	*Acrilan* 5 min
Green IB	Plain	Depth	fair	good	fair	fair	fair	fair
		Crock	fair	good	fair	fair	fair	fair
		Wash	excell	excell	excell	excell	good	good
		Light	good	poor	fair	fair	poor	good
		Strip	fair	good	fair	fair	fair	fair
	Cu+	Depth	good	good	good	good	good	excell
		Crock	poor	poor	poor	poor	poor	poor
		Wash	good	good	good	good	fair	poor
		Light	poor	poor	poor	good	poor	fair
		Strip	fair	fair	fair	poor	fair	fair
Blue IBC	Plain	Depth	good	good	good	good	fair	fair
		Crock	fair	fair	fair	fair	fair	fair
		Wash	good	good	good	good	fair	fair
		Light	good	good	v poor	v poor	good	v poor
		Strip	poor	poor	v poor	v poor	v poor	v poor
	Cu+	Depth	fair	good	good	good	good	good
		Crock	fair	fair	fair	fair	fair	fair
		Wash	good	good	good	good	fair	fair
		Light	poor	poor	poor	v poor	good	good
		Strip	v poor	v poor	v poor	v poor	v poor	v poor
Orange IRK	Plain	Depth	good	good	good	good	fair	fair
		Crock	good	good	good	good	fair	fair
		Wash	excell	excell	fair	good	fair	good
		Light	good	good	good	good	good	fair
		Strip	poor	poor	v poor	v poor	v poor	v poor
	Cu+	Depth	sl dull	sl dull	good	yellow	good	dull
		Crock	good	good	good	good	fair	fair
		Wash	excell	excell	fair	good	fair	good
		Light	fair	good	v poor	v poor	fair	fair
		Strip	v poor	poor	v poor	v poor	poor	fair
Pink IR	Plain	Depth	fair	fair	good	good	fair	fair
		Crock	fair	fair	fair	fair	poor	poor
		Wash	good	fair	good	good	good	good
		Light	poor	poor	v poor	poor	good	good
		Strip	poor	v poor	poor	fair	fair	fair
	Cu+	Depth	good	good	good	good	good	good
		Crock	fair	fair	fair	fair	poor	poor
		Wash	good	fair	good	good	good	good
		Light	poor	poor	fair	poor	good	good
		Strip	good	good	poor	fair	good	good

DISCUSSION OF RESULTS——The application of vat and leuco-ester dyes to the acrylic fibers by conventional methods gave dyeings having good light fastness, fair to good washfastness and poor crockfastness. When these dyeings were subjected to the surface-stripping test described earlier, most of them were stripped completely. It was concluded that application of vat dyes by continuous processes resulted in surface coloration only. The times and temperatures of the continuous processes are not sufficient to permit vat dyes to penetrate acrylic fibers. This behavior correlates with the chemical nature of these new acrylic fibers, which are inert and exhibit very little swelling in water, whereas cotton and rayon swell readily in water.

It was found that long steaming periods did permit dye penetration into these fibers. Furthermore, penetration of the dye occurred much faster when they were in the sodium-leuco form. This would indicate that vat dyes in molecular form (sodium-leuco) penetrate acrylic fibers more readily than vat dyes in colloidal (acid-vat) or pigment form. Because long steaming times were required for dye fixation, this process was not considered practical as a continuous method.

Although acrylic fibers cannot be dyed with vat colors by orthodox procedures to obtain penetrated fiber dyeings, commercially satisfactory colorations can be produced in light shades with leuco esters, reduced vats and vat acids. Special attention should be given to thorough soaping.

The acrylic fibers did not show the marked absorption of vat dyes at high temperatures characteristic of Dacron. The sensitivity of Dynel to temperatures above 240°F limited the study of heat treatments to Acrilan and Orlon. These two fibers show marked yellowing at 350°F or higher, which influences the final shade. Penetration of Orlon by vats and leuco esters is not greatly increased even at 440°F. Spectrophotometric measurements and study of ultraviolet fluorescence substantiated this result. Aside from Dynel, it must be concluded that chemical and physical differences between Dacron and the other two acrylics account for the differences in dye absorption at high temperatures.

It is interesting to observe that Orlon exhibits a polarizing effect in spectrophotometric measurements. To our knowledge this fact has not been recorded in literature. Acrilan, Dynel and Dacron do not show this effect.

It was discovered that Orlon, Acrilan and

Dynel that had been treated with cuprous ions showed increased affinity for many leuco esters. The fact that some dyeings required boiling nitrite and acid for development is a strong indication that penetration or true dyeing had occurred. It is apparent that leuco esters behave in much the same way as acid dyes.

CONCLUSIONS——1) Conventional continuous methods of applying vat dyes produce surface coloration on acrylic fibers.

2) Heat treatment of vat dyeings on acrylic fibers does not improve dye fixation to the marked extent observed on Dacron.

3) Cuprous-ion pretreatment of acrylic fibers enhances their affinity for leuco esters of vat dyes and improves fixation.

4) Continuous application of cuprous ion to acrylic fibers is practical.

SUMMARY

1) New methods of applying vat dyes and leuco esters to Dacron were developed, which produced dyeings with satisfactory light, washing and crock fastness.

2) A continuous process for dyeing acetate, acid or premetallized dyes on the new synthetic fibers was not developed.

3) An all-continuous method for the application of vat dyes and leuco esters to acrylic fibers was not developed.

4) A new technique was discovered whereby cuprous ions can be applied continuously to acrylic fibers. It was further developed that a unique feature of fabrics so treated is that they can be dyed with leuco esters as well as with acid dyes by batch-dyeing processes.

5) A new surface-stripping treatment was developed, which serves both to determine the extent of dye penetration and to produce dyeings of vat dyes and leuco esters on the new synthetic fibers, which are free from crocking.

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Meeting Report— BDTI Student Chapter

March 11, 1952
Fall River, Mass

ON MARCH 11th the Bradford Durfee Technical Institute Student Chapter held its second meeting of the year in the school auditorium.

The guest speaker, Kenneth H Barnard, Textile Resin Department, American Cyanamid Company, discussed resin finishes and supplemented his talk with a movie on the subject.

Respectfully submitted,
EDWARD W MAKUCH, *Secretary*

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Meeting Reports— PTI Student Chapter

March 13 and 27, 1952
Philadelphia, Pa

A SPECIAL afternoon meeting of the Philadelphia Textile Institute Student Chapter was held on March 13 at which Donald E Marnon, assistant to the technical director, General Dyestuff Corporation, and co-inventor of the Marhen Process, discussed "The Theory of Vat Dyeing."

On March 27th Mr Marnon spoke further on the subject of vat dyeing.

Respectfully submitted,
ALFRED W COWAN, *Secretary*

—◆ ◆—

South Central Section Announces May 17th Meeting Program

R WILBURN FREEZE, South Central Section Secretary, has announced the following program for the Section's May 17th Meeting at the Patten Hotel, Chattanooga, Tenn:

1) A P Roy, Dean & Sherk Co (Lawrenceburg, Ky) will speak on "Dyeing of Synthetic Yarns in Package Form".

2) E V Helms, Geigy Company, will present a paper on "Sequestering Agents". He will be assisted by B L Hathorne, director of Geigy's Textile Auxiliary Department.

3) The speaker at the banquet will be Grady Gant, personnel director of the Dixie Mercerizing Company. His subject will be "This Is Our Answer".

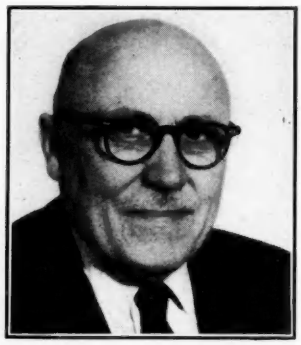
30th Annual Convention
Public Luncheon Meeting——

PART I—
MIXED FIBERS SYMPOSIUM*

Presiding: LEONARD LITTLE
Chairman, AATCC Research Committee

MR LITTLE: Ladies and gentlemen, I welcome you to this first general symposium to be held at an annual convention of our Association. The manager of this hotel tells me that this is the largest individual luncheon of its kind ever held in New York City. We appreciate your attendance and support.

Our National President, C Norris Rabold, will give you a brief address of welcome. Mr Rabold was born in 1903 and was graduated from Dickinson College in 1925. He took his first position with the Corn Products Corporation as a technical service man, and then joined Pacific Mills Print Works, where he was chemist in charge of analytical laboratories. He next became chief chemist in charge of research for the Union Bleachery in the South and is now director of research for Erwin Mills, Inc, also in the South. Norris and I had the pleasure of traveling abroad last summer, where he proved to be an ambassador of great competence for the AATCC in selling an appreciation of our work for the textile industry. Our president!



Leonard S Little

Mr Rabold: We of the Association are very happy to welcome you here at this luncheon and symposium for those who are interested in mixed fibers. The topic is timely, as the many new fibers now available have presented our dyeing industry with many a problem in processing mixtures. Your questions and the answers of this panel of experts should be of considerable value to yarn and fabric processors, to dye manufacturers and to all those engaged in merchandising textile products.

This luncheon is an illustration of how our American Association of Textile Chemists and Colorists contributes to the advancement of our industry.

I wish to thank Leonard Little, Robert Bonnar, J Spencer Love, the Committee and also the panel of experts for making this outstanding event possible.

Mr Little: Norris is not using his hands so much now in speaking as he did in Europe where we could not talk the languages very well. But in English his words alone are sufficient.

I am honored now to present to you J Spencer Love, who will deliver an opening address to introduce the topic of discussion for the day. We are indeed fortunate to have him do this for us as we consider him one of the leading textile industrialists in the United States. A brief outline of his career has already been published in our *Proceedings* on page P637 of the issue of the *American Dyestuff Reporter* for October 1, 1951.

It is with great pleasure and honor that I give you J Spencer Love.

* Held by the AATCC at its 30th Annual Convention for the interested public attending a luncheon at the Hotel Statler on Thursday noon, October 18, 1951.

FROM WONDER FIBER TO WONDER FABRIC—A CHALLENGE TO MANAGEMENT

J SPENCER LOVE
Chairman, Burlington Mills Corporation

A FEW WEEKS ago I read, like many of you, that our country is engaged in one of the most fascinating races in history. The winner it seems will be that country which succeeds in placing a man-made planet out in space. This is dramatic evidence that we are living in a highly scientific age, and, although you men are not atomic or space scientists, you are more or less in the same fraternity with those who are experimenting with this space planet. For, as we read about space planets and atomic fission, we also hear about fabrics of the future—fabrics which will hold their crease for the life of the garment, fabrics which are warm, lightweight, and can be made into completely washable suits, fabrics which achieve the ultimate in abrasion resistance, strength, and adaptability for infinite end uses. You are the designers of such revolutionary fabrics, and I am happy that your efforts are bent in the direction of good rather than in building an atmospheric platform from which destruction may be hurled at the earth. I think it is important that we in the textile industry never lose sight of our goal of providing better and better products at lower and lower prices. What I want to speak to you about is a vital tool in reaching that goal—management.

J Spencer Love

As you are representatives of the best technical brains in our industry, it would be most presumptuous of me to discuss in detail the many scientific advances that have been made or those that lie ahead, for each of you is in a far better position than I to speak with authority on that subject. Rather, I

would like to deal with another important facet of our business. Thus, the title of my remarks: "From Wonder Fiber to Wonder Fabric—A Challenge to Management."

Some of you may well ask why I have chosen such a title. Isn't it, as several may say, taken for granted that a wonder fiber will produce a wonder fabric? My own emphatic answer is: No! Those of you who have gone through the trials and tribulations from fiber to fabric realize that it takes a lot of research, experimentation, sampling, and investigation of all the details connected with spinning, conditioning, mixing, twisting, weaving, dyeing and finishing before a satisfactory fabric is produced.

Thus, at the outset, I want to emphasize two points: One, we are indeed standing today on the threshold of some of the greatest fabric advances yet open to the textile industry, and, two, this advancement will not come of itself. It will take hard work and a substantial period of time. And it will take wise and alert direction by management to produce these so-called wonder fabrics.

Our industry tends to forget that a fiber is not a piece of fabric. At the risk of sounding elementary, let me emphasize: it is a raw material. Just what does it take to make this basic substance a fabric of utility and beauty which can be put into garments at a cost people can afford to pay? It takes constant research and experimentation to adapt the fiber to its best end use. It calls for many skills and infinite pains in spinning, weaving and processing. It needs meticulous care in dyeing and finishing. It calls for regular testing and wear-testing to obtain the highest-quality standards. And it demands astute and imaginative merchandising and promotion. Then too, all this work costs a "pretty penny." For example, as a company, we are spending $4,000,000 a year in this increasingly important area of research, experimentation and quality control. This compares with $1,500,000 in 1947 and $500,000 in 1941 in the same fields. So you can see what the trend is in our company, and our relative position in the industry is now about the same as it was before. This expenditure for research indicates what we believe must be done to achieve the best possible from all fibers. Thus, the raw fiber must indeed be put through the mill.

We have all read and heard about the many new wonder fibers that are now in the development stage. All indications are that they are truly wonder fibers. I believe, however, that our industry, my own company included, in their anxiety to move forward with new developments has had the tendency to overpublicize these fibers long before they are in commercial production. Perhaps it would be well for us to take a lesson from our friends, the automobile manufacturers. They do not publicize their new lines until a few weeks before the models are in the showrooms for the consumer to buy. Certainly we must face the fact that most of these new fibers are not yet in commercial production by our research-minded producers. Moreover, we are a long way from knowing all the characteristics from a fabric standpoint of each of these fibers, not to mention the tremendous possibilities and directions of blends. Whetting the appetites of our manufacturers and consumers for these revolutionary new textile products long in advance of actual volume production has detracted interest from the products we are selling today. I suggest that each firm within our industry give serious consideration to this point on overpublicizing new developments before commercial production is available.

Here, let me add a pertinent word with respect to our older fibers—the so-called man-made rayon and acetate, and the wholly synthetic nylon. We have accomplished a great deal with *those* wonder fibers. After many years of experimentation we are still continuing to develop wonder fabrics from these established fibers. In our eagerness and excitement over some of the newer fibers let us not forget that there are still tremendous opportunities open for improving fabrics of these yarns and broadening the base of their end-use applications.

Too often, I believe, we are inclined to be like the advertising experts. You all know how often a panel of agency men will choose what they think is the best sales-pulling copy and then, lo and behold, that final arbiter of practically everything in America—the little woman at home—will decide exactly the opposite.

The reason this happens is fairly obvious, and, just as it is true in the advertising fraternity, it is often true of us in the textile industry. We fall into the bad habit of all businessmen—the rather satisfying, but unrewarding, practice of talking to ourselves. To be more specific, we say to ourselves, "Isn't nylon a wonder fiber?" "Isn't 'Orlon' acrylic fiber or 'Acrilan' the perfect fiber for year-round clothing?", and then we cap it off by saying, "Let's put some 'Dacron' polyester fiber, 'Dynel' acrylic fiber, 'Vicara' protein fiber or any other new fiber into this fabric and then sit back and watch the profits come in." But it just doesn't happen that way. In a little while I will outline for you what I think we must add, what we must do, and what we must give in order to reap the just rewards of that which has been given to us to work with.

But in order for us to visualize the broad vista of opportunity in front of us, I would like to trace briefly our path up to this threshold.

We have come a long way in the man-made textile industry. It's only about a 25-year span that makes up our entire industry. It's even much less time since we've really put our backs to the wheel and made tremendous progress. Nothing indicates the fascinating growth of the man-made fabrics industry more than the shift in fiber consumption in this country since 1925. In that year, cotton represented 86.6%, wool 9.9%, silk 1.9% and chemical fibers only 1.6% of all fibers. By 1940, cotton was at 81%, chemical fibers had risen to 10%, or second in rank, while wool stood at 8.4% and silk at 0.7%. By 1950, the figures read 68.8% for cotton, 21.8% for man-made fibers, 9.3% for wool and .08% for silk. In the last 30 years the use of rayon and acetate have risen from 8,700,000 pounds to 1,200,000,000 pounds. For the purposes of this discussion it is even more important to point out the spectacular rises that have taken place in the end uses of rayon, acetate and nylon fibers. In 1929 women's rayon suits were not even mentioned in the census. By 1950 over 40% of all women's suits were made of rayon and acetate fibers. About 50% of all women's skirts are now made of rayon and acetate fabrics. Over 70% of all unit-price dresses use rayon and acetate. Over 75% of all women's blouses are manufactured of man-made textiles.

We all know about the spectacular growth rayon, acetate and nylon have made in men's summer suits. Five years ago only 10% of men's summer suits were made of these fibers. For the first time last year rayon, acetate, and nylon summer suits outsold tropical worsteds and worsted gabardines by 56% compared with 40%. As late as 1946 rayon and acetate-fabric slacks accounted for about 25% of the total trouser production. By 1950 there were more rayon and acetate slacks made than wool (about 20,600,000 rayon to 19,100,000 wool). Rayon and acetate are used to a great extent in bed blankets, rainware, bathing suits, women's sportswear, men's underwear, carpet rugs, and many prewar volume fields such as lingerie, hosiery, linings, decorative fabrics and upholstery cloths, sweaters, dressing gowns, bathrobes, linens, and over-the-counter yard goods.

Those few figures tell the story. The strides in our man-made textile industry have been nothing short of tremendous. It has expanded our field from a few end uses to a point where the fibers are used in practically every textile manufacturing industry. How has this field been so broadened? It has been done generally in two ways: One, through the hard work of technicians like yourself who have improved our processing methods, our weaving operations, our dyeing and finishing techniques, and the necessary establishment of rigid standards on quality. And, two, management's vision has directed those efforts to their ultimate payoff. It is on this latter point that I want to spend most of my time—particularly in relation to the chal-

lenge that the old and new man-made fibers present to management.

First, let me say that, like all industry, we need one general frame of reference in which to work. For us in the textile-apparel industry, it is simply this: to make a greater abundance of good fabrics for good clothing, of good taste and fashion, available to more people at prices they can afford.

Therein lies the challenge to management. How will we use the wealth which our fiber-producing industry is handing to us? What will we do with this wealth? Will we add to it and pass on greater benefits, or will we be content to dress up the wealth and pass it on, in really unchanged and unsatisfactory form? The challenge then is to take these wonder fibers and make them into truly wonder fabrics.

Now, what are some of the elements of management which are so important to accomplish this end? Let me list just a few of the more important:

1) To experiment and develop every possible use for every fiber so that it ends up as the best fabric possible for a suit, a coat or a dress.
2) Initiate an industry-wide promotional effort immediately to get behind the wonder products of our established man-made fibers and to lay plans in the future to aggressively tell the story of the newer fibers and fabrics when they are in volume production. Certainly, in order to sell these new products, we must of necessity tell the buying public just what qualities and characteristics they possess. I think our industry has been negligent in not telling its story in a unified way.
3) To merchandise our fabric honestly with respect to the job each can do for a particular apparel, home-furnishing or industrial field rather than on the short-sighted novelty or publicity value of any fiber.

On the first point, our forward-thinking yarn producers are now passing on to us a tremendous opportunity. The fiber of one company has limitless possibilities for fabrics that require warmth. Another is ideal for lightweight clothing that can be laundered. Still another is outstanding in its abrasive characteristics. But having one or more of these fibers at our disposal does not, by any means, put an end to our task. We must take each fiber and try it in all fields. Will it do the best job for us in men's suitings, women's lingerie, or work clothing. Or will it be still another fiber that is best for these fields?

Perhaps, as expressed by the theme of your meeting, it will take the blending of several of these new fibers with our existing man-made fibers or with our natural fibers to produce the best possible fabric for each individual end use. I feel we have only scratched the surface in this important field of blends. Much progress has been made but there is still a lot to be done!

I am sure you will forgive me if I call upon our company's experience. For many years we had been guided in our research and development work by this one basic principle. That principle is, "Be right rather than first." It is nice to be both, but, with these many new developments in our field, that is not always possible. Therefore, let us accept rightness as the all-important point. To this end we maintain what we would like to feel is the most up-to-date of the experimental programs in the weaving industry including a separate spinning, a separate sample-weaving and a separate dyeing and finishing laboratory. Whether it be one of our established man-made fibers or one of the newer fibers, we make several thousand samples a year to be analyzed, tested, and perfected. Our unique wear-testing program of some 450 individuals around the country gives us first-hand reaction on garments made of any new fabrics. Often I am certain that we spend thousands of dollars that show no tangible results. Nevertheless, as mentioned before in reference to our current expense of $4,000,000 a year, this work is necessary to develop the best possible fabric.

So much for research and experimentation. But there is still another avenue open to us. And we should definitely use it to find out just what is the best fabric for any particular end use. This avenue is actually a two-lane highway. We must get information to guide us from fashion experts, designers, manufacturers and retailers. Perhaps even more important, before we plow ahead, we must get the facts by "asking the man or woman who owns one."

Along these lines, I would like to tell the story of a young Congressman from Missouri. As he was about to leave for Washington just after he was elected, he asked an older statesman from his home grounds for some advice. What should he do about the letters he was sure he'd get from his constituents? "Son," the wise old jurist said, "you'll get a lot of letters. Better read them all. And especially the ones writ with pencil on tablet paper."

To fulfill the promise of wonderful fabrics from all, truly wonder fibers, from rayon and acetate on down, we are going to have to "read the ones writ with pencil on tablet paper."

Now, after we have read the handwriting on the wall, there is another very vital step management must take to bring all of these efforts to fruition. And that one thing is to inform the trade and the public about what we have. As I said, I think this should be one of our more important objectives.

For many years it has seemed to me that the rayon and acetate industry has grown up to a greater maturity than many people recognize. Despite this maturity, we still act in many ways like a house divided. What we need in simple language is one industry-wide promotion body; a council, perhaps, to tell our story. This body should embrace all members of the man-made textile community. It should include yarn producers, weavers, converters and dyers and finishers. What should it do?

1) It should serve as a clearing house of information for fiber and textile mills, manufacturers, retailers and consumers. It should not only disseminate information on the progress we shall make from now on, but fill the vacuum of information on all we have already done. In 25 years our industry has achieved as much as other groups have achieved in centuries. It is a proud accomplishment.

2) It should act as a national, industry-wide spokesman wherever it seems necessary. Being a resident of Washington, I recall several instances where our industry has come off second best to our agricultural friends primarily because we did not speak out as a group. For an industry the size of ours, it is inconceivable to me that we should not have one unified strong voice.

3) It should be an aggressive promotional body for all our products whether it be in working with manufacturers, retailers, fashion magazines, newspapers or consumer groups. Such promotions or publicity must take a positive approach to consumers on the qualities of our products rather than to tear down or attempt to stop the use of competitive fibers. Let's not be guilty of following the negative approach as practiced by some of our friends in other branches of the textile industry.

There are many such groups which should spur us on and, perhaps, give us a framework to improve upon. The National Cotton Council, for one, has done an outstanding job for that industry.

In summary, our industry has made giant strides through technical advances and management vision. We have new fibers with fantastic vistas of opportunity. We have so-called "old" fibers that have proved their worth and can still be improved to do finer jobs in present or new end uses. The challenge to management is to use them wisely, to find out what they are best adapted for, to research and experiment, to improve quality and performance, to find out what the public wants and to get to them goods that are better adapted to fill those needs than the world has ever seen.

We must use our wealth to add, with the utmost of our capacity, to the good of all men.

The other day I came across a quotation from Bruce Barton, which I think is apropos of my remarks. It was as follows:

"There are two seas in Israel. One is fresh, and fish are in it. Green verdure

lines its banks; children play along its shores. This sea gets its sparkling water from the river Jordan. Men build their houses near it, and every kind of life is happier because it is there. The river Jordan flows on south into another sea. Here, there is no splash of fish, no fluttering leaf, no song of birds, no children's laughter. This is the difference. The Sea of Galilee receives but does not keep the Jordan. For every drop that flows into it, another drop flows out. The giving and receiving go on in equal measure. The other sea is shrewder, hoarding its income jealously. Every drop it gets, it keeps. The Sea of Galilee gives and lives. This other sea gives nothing. It is named the Dead."

Which shall it be? We certainly have every opportunity to take the wealth we have, to add to it, and to pass it on like the Sea of Galilee. We are on the threshold of a great forward-moving era and I am confident that our industry will meet that challenge. Thank you.

Mr Little: We sincerely appreciate this inspiring message from J Spencer Love. Perhaps many here do not realize how large an organization AATCC has grown to be. We now have over 7000 members distributed over the textile industry of not only the United States but of the whole world.

A man who is very active in our work and who has given unstintingly of his time and effort is J Robert Bonnar, at present a vice-president in our Association and former Chairman of the Research Committee. He will preside over our symposium. Mr Bonnar was born in 1906 and was graduated from the Massachusetts Institute of Technology in 1927. He was formerly technical director of the American Print Works at Fall River, Mass, and for several years has been director of the Technical Department of the General Dyestuff Corporation. Bob and I have worked together on the Executive Committee for Research, in which he was a tower of strength. He is a man of outstanding character, a fine community leader, and a member of whom we are proud. I present Bob Bonnar, who will now preside.

Mr Bonnar: Thank you, Mr Little.

Today mixtures of three or more fibers are as common as two used to be. Mixtures involving natural fibers are almost as common as those being made entirely of the synthetics. In other words, we have before us blends of various synthetic fibers as well as blends of synthetic fibers and natural fibers. Why the necessity for so many blends and what problems they bring will be touched upon by various members of our panel, I am sure.

At present there are between fifty and one hundred different kinds of man-made and synthetic fibers alone that are available in the United States. I refer to types of fibers that can be analyzed in a piece of fabric as being different from any others within the fabric. The trend is for more and more types to be added constantly. Let us look at the commonest type of man-made fiber, the cellulosic.

The tremendous growth in importance of these fibers can be judged from the estimated consumption for 1949 of one billion pounds, representing approximately one-fourth of the amount of cotton fiber used for the same period. Acetate rayon now represents approximately 50% of this production. In addition to the differences in chemical constitution, which modify the properties of these two classes of fibers, we have differences in the physical properties within each group. High-tenacity rayons produced by reorienting the structure of ordinary rayon fiber possess unusual strength but must be distinguished from the regular types because they are more difficult to dye. Both of these classes of fibers are produced in filament and staple form. Viscose rayon may be crimped by chemical means or an inherent crimp can be brought out in the finishing bath. We even have a fiber with an acetate core and a viscose surface produced by partial saponification. Natural cellulosic fibers are also presenting some new problems with such variations as acetylated cotton and chemically modified flax.

Probably the greatest complicating factor today in mixtures of fibers are the hydrophobic types. The first one of the hydrophobic types to achieve great poundage of course is nylon. But even before the problems of handling nylon have been solved, a whole new class of hydrophobic fibers have come into being: the acrylics. At present there are at least three types of acrylic fibers being used in textile mills, and these three types vary between themselves more than do viscose rayon and acetate. In addition, we have the polyester and protein types of fibers, which are finding increasing applications. Whereas the production of most of the newer synthetic fibers is limited at the present time, new production facilities are on the way. This confidence is a reflection of the optimism created by favorable consumer evaluation. These reports would indicate that individual fibers will find their own level and be utilized for end uses for which they are particularly suited. They should not be considered as substitutes but as building blocks which contribute a new value to the finished product. A scientific approach to fiber utilization will also point out limitations in fiber blending, which will directly influence manufacture, dyeing and finishing procedures.

The fibers we now have by no means represent the end of those that are coming. The marvelous acceptance of nylon, the various price fluctuations of natural fibers, the acceptance of rayon—all these factors have opened the door for the introduction of many, many new synthetic fibers. Before very long we may have added another type of nylon, we may have a class not now being manufactured, and we shall surely get from abroad fibers that have no counterpart here.

Why don't each of these fibers go its own way instead of mixing one with the other? Not too many years ago, cotton was cotton, wool was wool, and only in a few instances, such as merino yarns, did the two mix. When they did mix, cotton was generally considered an adulterant. But can we say today that addition of nylon adulterates wool or can we look for all-nylon suiting fabrics? Of course not!

The blending of fibers opens possibilities not found in the use of each fiber alone. Blending makes possible types of fabrics not practicable even by modifications of fibers or—heresy—by chemical finishes.

But all mixes of fibers are not good blends. Every mixture represents problems, and, in some cases, as I am sure we will shortly hear, some mixtures cause more trouble than they do good.

Blends are greatly complicating the jobs of all textile chemists and colorists. This symposium has been given a prominent part in our Annual Convention as recognition of the importance of mixed fibers. We have assembled here an impressive group of persons, all of whom have played important parts in the growth of mixed fibers. They have graciously agreed to answer your questions to share their knowledge and experience with you. It is this type of co-operation and collaboration that has given the AATCC its pre-eminent place in the textile field today.

Before proceeding to the questions, I want to extol the excellent work of Leonard Little, Chairman, George Baxter, Cochairman, and the other members of the Committee that so ably arranged this meeting. I want to thank Paul Choquette and the beautiful young ladies who are helping here today. On behalf of all of us, I want especially to thank the members of the Panel, experts in the textile industry whose knowledge and practical experience will make it possible to get worthwhile answers to the questions that will be posed in this symposium.

As you finish writing your questions, I would like to call your attention to the fact that each member of the Panel has his name on a placard in front of him. The young ladies will now collect your questions, and I shall begin firing them at the experts. In the report of this meeting in the *Proceedings,* names will not be connected with either questions or answers.

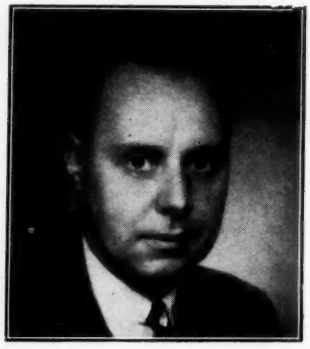
PANEL

Ira Altman
Partner, Cavalcade Fabrics
William D Appel
Chief, Textiles Section, National Bureau of Standards
David Askenase
Rose Brothers
Fred Bantz
Vice-president in charge of merchandising, J C Penney Company
Ernest H. Benzing
Technical Director, American Bemberg Corporation
Frederic Bonnet
Advisor to President, American Viscose Corporation
Robert Burns
Celanese Corporation of America
Paul J Choquette
Co-ordinator of Research, Tech Dept, General Dyestuff Corporation
John N Dalton
Director of Chemical Dept, Pacific Mills Worsted Division
Arthur W Etchells
Technical Director, Hellwig Dyeing Corporation
John J Goldsmith
Vice-president, Hess, Goldsmith & Company
Otto C Haufe
Turner Halsey Company
George H Hotte
Technical Director, A M Tenney Associates
Richard Kropf
Vice-president of research, Belding Hemingway
Waldemar Kuenzel
Executive Manager, Fabric Division, Deering Milliken & Co, Inc
Eugene Lutz
Head of Textile Development, Burlington Mills (N Y)
Vivian McCollom
President, Allentown Converting Company
Paul L Meunier
Manager of Sales Development, Dyestuffs Division, E I du Pont de Nemours & Co, Inc
Joseph B Quig
Assistant Manager, Development, Rayon Department, E I du Pont de Nemours & Co, Inc
E W Rugeley
Technical Director of Textile Fibers, Carbide and Carbon Chemicals Division
Harold W Stiegler
AATCC Director of Research
Fred L Young
Consultant, Virginia-Carolina Chemical Company

QUESTIONS AND ANSWERS

J R BONNAR

Moderator



J R Bonnar

Question: Why is Dacron polyester fiber blended with other fibers?

Answer: One of the first fabrics containing Dacron to be promoted contains 55% Dacron and 45% worsted in an 8-ounce tropical suiting. The worsted gives greater resistance to static and greater moisture absorption; the whole fabric, for its weight, gives outstanding performance to the consumer in resiliency, shape retention and freedom from puckering under any climatic conditions. It is superior, in my opinion, to any all-worsted material on the market.

Q: What precautions must be taken to minimize static in processing synthetics?

A: Nothing need be done with fibers as received since manufacturers apply antistatic agents to fibers before delivery. If the antistatic agent is removed during processing, it should be replaced. All manufacturers stand ready to advise you about the proper antistatic agent.

A: If a mill handles synthetics, it probably operates with high humidity, such as 50 to 65%. But a humidity cannot be maintained that is sufficiently high for all hydrophobic fibers. When we handle Dynel acrylic fiber, we apply additional hydroscopic agent in the opening department. After wet-processing operations, such as scouring and dyeing, additional antistatic finish must be applied.

A: High mill humidity is desirable, but if it is too high, some finishes become sticky. We use about 60% R H for Orlon acrylic fiber and Dacron polyester fiber.

Q: Can Orlon acrylic fiber and wool be dyed solid?

A: Unfortunately, we do not know how to do that. When the cuprous-copper method is used for acid dyes on Orlon, any wool present absorbs about 95% of the color.

Q: Do current methods of dyeing Dacron polyester fiber affect its physical properties enough to influence succeeding operations?

A: If antistatic agent is removed in dyeing, it must be replaced.

In package dyeing, winding must be well done. Tight places in a package under heat and pressure may change color and may change the running qualities of the yarn. The use of benzoic acid in Dacron dyeing, according to our experience, improves yarn texture.

A: In the preparation of a Dacron top, care must be exercised to give the fibers room to shrink somewhat.

Q: Whose job is it to see that correct construction, dyeing and finishing have gone into a mixed fabric for satisfactory consumer end use?

A: Teamwork, as mentioned by Mr Love, is important, and the dyer has a major responsibility.

A: The whole mill must bear the responsibility.

A: The converter in this instance must exercise the function of management and see that the final fabric is satisfactory. The converter must co-ordinate everything to bring satisfaction to the consumer.

A: The manufacturer and the converter, if both are involved, must bear joint responsibility if the retailer is to give satisfaction to the customer. But where there is a chain of responsibility, it is difficult to pinpoint that responsibility properly, and a high degree of co-operation along the whole line is necessary.

Q: Do the new synthetic fibers spin well on conventional systems?

A: I think most of them spin fairly well on conventional machinery, with some changes in settings. Isn't it true that the fiber must come before systems for processing it satisfactorily? Improvements in machinery for new fibers will come steadily with experience.

What we need is a universal system that will handle all fibers. I am sure mill men would welcome such an innovation. We do have spinning machinery that handles some of the new fibers and blends fairly well. Work needs to be continued on opening, picking, carding, and drawing.

Q: When and how is a wool-nylon fabric stabilized for tailoring?

A: These fabrics are conditioned for tailoring in the same manner as all-wool

materials; nothing extra or different is necessary. At least, that has been our experience.

A: We have had considerable experience with this problem. There are three factors that influence the setting of a wool-nylon fabric: its weight, the proportion of nylon, and the scorching temperature of wool. We have found that 12 ounces is the limiting weight of the material. The limiting amount of nylon is on the lower side, that is, a minimum of 10%. The limiting temperature to which the fabric can be heated without injuring the wool is 300 to 310°F.

Conventional wool-setting processes are not wholly satisfactory for fabrics under the weight limit that I have just indicated. Under conditions of high humidity you will get puckering and a material that will be difficult to tailor. If we cannot use conventional processes, such as crabbing, of course we have to find some other way of doing it; and indications are, according to experimental evidence, that a wool-nylon fabric can be set by a chemical treatment at a high temperature. The conditions that require attention are the temperature and the pH of the chemical treatment.

Mr Bonnar: As there are some duplications among the questions, some will be combined and reworded.

Q: Here is one that you may refrain from answering for commercial reasons if you wish. When do you expect that fabrics of polyester fiber and of acrylic fiber will be in good supply?

A: I cannot answer exactly. We expect to bring the plant for Orlon acrylic staple fiber into production during 1952, possibly in the summer, and the plant for Dacron polyester staple and continuous-filament fiber about the middle of 1953. That is as much as I can say. But as Mr Love pointed out, there is quite a chain of circumstances between just having the fibers and producing them in quantity.

Q: Does the converter find it profitable to make certain that the serviceability of his merchandise will meet end-use requirements?

A: I believe that question goes back to the previous question of responsibility. As a given fabric made by a given mill, sold to a converter, and converted through a dye plant might be used for any number of purposes, there is no question that not only the responsibility but the advantage of the converter demand that he inform the weaver and the dyer about the end use. In many instances the weaver and dyer will have no idea of the end use unless informed by the converter.

A: I go along with what has been said, but I want to add that the converter often does not know what the end use is going to be. It is then the responsibility of the dress manufacturer or retailer to be sure that he gets the right fabric for a certain end use.

A: I don't know if you can all see these placards plainly, but I have Burns on one side of me and Hotte on the other. That does not mean, however, that my answer will be well done.

I agree that the converter should be sure that a fabric meets end-use requirements, providing he knows the end use. It is profitable for him to be conscious of end-use requirements so as to avoid complaints and the paying of claims. It is also profitable for him to maintain the good will of the cutter and consumer, who will be appreciative of the effort of the converter to guard against misapplication of a product.

Q: Are any sewing threads made of mixed fibers?

A: No. We are concentrating in our plant on the problem of functional serviceability of seams. Although eventually we may come to threads of mixed fibers, at present we can get the necessary properties in seams with threads made up of one fiber.

Q: Is it necessary to heat-set Dacron polyester fiber in order to obtain shrinkage control?

A: Conventional worsted or semifinishing procedures should be sufficient. By the time Dacron goes through these processes, it has been exposed to considerable heat, which should be sufficient for spun-staple fabrics.

However, we are now studying the problem of heat setting.

In the case of continuous-filament Dacron, we have a different end use where ironing at high temperatures comes into question. For these fabrics, we must then finish at a temperature that is higher than that to which the fabric will be exposed in use. If a Dacron dress fabric is to be ironed in a home at the rayon temperature of 325°F, then it must be heat-set at about 375°F.

A: I might add that spun-Dacron fabrics are not normally heat-set but are controlled to be washed at 160°F. In the case of filament Dacron, we have found that heat setting at too high a temperature impairs the resistance of Dacron to stretch. We therefore set it at the lowest possible temperature, which we think is 350 to 400°F. It can then be washed with cotton at the boil.

A: It should be added that, in the case of filament Dacron, heat setting is normally conducted at 325 to 375°F. If this range of temperature is exceeded, the fabric will continue to shrink and a considerably firmer, harder texture will result.

Q: What can be done to improve the abrasion resistance of resin-stabilized fabrics?

A: I believe there is considerable room for research on that problem on the part of the resin manufacturer. There is also need for careful control by those who apply resin finishes. When resins are properly applied, however, there should not be much impairment of abrasion resistance.

Q: Is the AATCC investigating the difference between sunlight and Fade-Ometer exposure on the light fastness of dyed synthetics?

A: Yes, the AATCC is investigating this problem. We had heard that when there is a difference in fading, Fade-Ometer-exposed material always fades most. Although this is usually the case, our experiments show that often the reverse also takes place.

By arrangement of the Executive Committee on Research, the Research Committee, and M J Babey, chairman of the Light-Fastness Committee, we are investigating the problem. The Committee is compiling a list of dyes that are known to cause this anomaly, this irregular difference in fading in sunlight and artificial light. Dyeings on fabrics of the newer fibers (using dyes on this list) will be subjected to an interlaboratory test, and the results will be published in the *Proceedings* in the *American Dyestuff Reporter*. The AATCC will appreciate any assistance or information that anyone can give us in this work.

Q: What is the cause of seam puckering observed in sewing mixed-fiber fabrics?

A: The term "seam puckering" is a very loose usage for a description of the phenomenon that occurs when a seam is stitched on not only mixed fabrics but on any fabric. One has to study the seam carefully to determine what the occurrence has been. Puckering can be roughly divided into four categories, as follows:

1) A puckered appearance due to drawing, as a thread through a duffle bag, or a rope through a duffle bag, which is pulled up and tends to draw the seam together.

2) Shirring, which is done intentionally by differential feeding of the materials being stitched together. In the first case of drawing and in the second case of shirring, both of these conditions, if not required, can be taken care of by proper selection of sewing machine, thread, needle, operation, etc.

3) A third type of puckering is attributed to dimensional changes from shrinkage swelling due to changes in relative humidity.

4) Probably the most important cause of puckering is what we in research call "cleaner displacement". This is due to the fact that these fabrics have a planer

density, that is, they are incompressible in the plane in which they lie. Therefore, when a needle is introduced, even without a sewing thread, a puckering occurs. This type of puckering cannot be remedied by changes in thread, conditions of sewing, or fabric construction or by finishing so as to prevent slippage.

A: I believe a lot of puckering can be eliminated by watching the tension on the sewing machine. Even tension on both top and bottom will eliminate a great deal of puckering.

Q: What are the prospects of improved wash fastness in acetate fabrics?

A: Well, I believe that today we have adequate wash fastness in acetate fabrics, particularly in those that are washed in the home at temperatures below 150°F. Only rarely are they washed above that temperature, and then dark shades will give trouble.

A: I agree in general with the previous speaker. When we think of still better wash fastness, we come to vat dyes. These can be applied in light shades by the pad-steam process without saponification of the fiber or by use of leucoesters of vat dyes without any alkali at all.

In addition to that, we have seen much in the patent literature and we have heard of some trials in this country where vat dyes have been applied in jigs. The process is disclosed in British patents by Sutton. At least some of those disclosures mention the use of alcohol in the dye vat as a swelling agent and ammonia as the alkali.

A: Aside from vat fastness, it is my opinion that full utilization is not being made of those acetate dyestuffs that are already available as far as wash fastness is concerned. It is impossible to get a full range of acetate shades that stand wash test No. 1, and some heavy and all medium shades that stand wash test No. 2.

Although better fastness might be desirable, in one wash-machine exhibit upstairs are shown several acetate dresses and some acetate-viscose men's suits that have been worn last summer and have been washed several times in a Westinghouse washer. Furthermore, acetate textiles wash well at a moderate temperature without alkali or large amounts of detergent.

Although better wash fastness for acetate may be desirable and we may get it some day, we can do quite well with what we have now. Naphthol dyes are fast on acetate but the color range is limited.

Q: Does Vicara zein fiber come in different grades?

A: We have what can be called two types, white and dull. The dyeability of these two types is the same. Vicara is now much more uniform in quality (dyeability and color) than when it first came out.

Q: Is there a laboratory method of measuring abrasion resistance that correlates with change of fabric appearance in use?

A: In general, no. I hate to say that in view of all the work on abrasion resistance at the Bureau of Standards. Many abrasion machines give useful results, some of which do correlate with use for some fabrics. The problem of abrasion, however, is very complicated.

A: Some people, such as Burlington Mills, use abrasion tests but do not depend wholly upon them. They also subject fabrics to practical use because they realize that use does not always parallel laboratory tests.

A: I should like to commend the fine job done by Steve Kennedy of the Quartermaster Corps in Philadelphia in correlating laboratory abrasion tests with the wear resistance of some fabrics. We think that the Stoll Abrasion Tester developed at the QM in Philadelphia shows great promise in evaluating some garment materials, especially spun-rayon shirting fabrics, for serviceability in normal use.

Before people stampede to the Stoll machine, however, I must warn you that laboratory tests with this machine must be properly evaluated by experts with much practical experience. Competent personnel and much experience are necessary to correlate laboratory abrasion results and actual wear tests.

Q: Where has Acrilan acrylic fiber found its greatest use?

A: As Acrilan is still in the initial stages of pilot-plant production, this question can be only provisionally answered. Preliminary results from fabrics in use, however, indicate that Acrilan is suitable for suitings, overcoatings, blankets and stiff moutons. A characteristic of this fiber is that it gives fluffiness to a fabric. It is also very resistant to creasing, that is to say, wrinkles in fabrics containing Acrilan come out when a garment is hung up for awhile.

On the other hand, when a material containing Acrilan is given a crease by a proper procedure, the crease remains permanently.

Q: To what extent is an educational program necessary to assist the retailer serve the consumer better from the standpoint of labeling and advertising?

A: That is difficult for an old-timer from American Viscose to answer, who saw a plan for education and quality control discontinued because it was too expensive. I think proper informative labeling from mill to consumer is important for all kinds of materials of all the synthetic and man-made fibers.

Q: Is the dyer asked by the designer to do the impossible?

A: Although, after J Spencer Love's excellent address, nothing should be called impossible, there are some things suggested by the designer to dyers and finishers that come within the realm of economic impossibility. It is true that techniques are known for attaining shrinkage resistance, crease resistance, durable water repellency and other desirable characteristics, and yet these cannot be produced at costs that are insignificant. If the designer asks that, then he is asking the impossible.

As an instance of a difficult problem, I should like to cite the demand for a full line of shades on a fabric containing a blend of 75% viscose, 12½% acetate and 12½% Acrilan.

Q: What effect will the use of blends of wool with synthetics have on shoddy or reworked-wool processing?

A: The use of blends containing Dacron, Acrilan or Orlon will present a real problem for the manufacturer of reprocessed wool. These fibers are very fast to mineral acids and cannot be readily removed by carbonizing. The problem may be solved in some other way than by carbonizing, but at present it looks difficult.

Q: What blends containing Orlon acrylic fiber can be union-dyed?

A: If you mean dyeing solid shades in one bath, that is very difficult. If the Orlon is dyed in the form of top or stock, then the wool in a blend can be cross-dyed with acid or chrome colors. Orlon-rayon blends can be dyed solid shades by a two-bath method, the rayon being dyed with vats and the Orlon being topped with acid colors by the cuprous-ion method.

In the case of Orlon-nylon blends, much depends upon the construction of the fabric. For example, the Orlon pile of a velvet can be more heavily dyed than the nylon by the cuprous-ion method, and the nylon can be filled to shade with acetate dyes in a soap bath. A taffeta containing Orlon and nylon constitutes a difficult problem as the nylon gobbles up most of the color. Up to the present time that problem of getting a solid color on this type of fabric has not been solved.

When Orlon and acetate are present in the same piece of goods, we visualize another serious problem because, in order to build shades on the Orlon, we usually have to use a carrier of some kind, particularly if the Orlon is of type 81 or fiber stock. When carriers are used at temperatures near the boil, the effect on the acetate can be pretty serious. We have noted a loss in tensile strength of about 40%, in some cases, in the acetate portion.

Q: How does the average dyer keep

up with technical progress?

A: I think it is safe to say that, in the dyeing and finishing industries generally, there is very little pure research going on. There are excellent reasons for this, most of them economic. But the dyer and finisher is given the opportunity of helping correlate the research of others. He is heir to fine research carried out by yarn producers, by dyestuff manufacturers, by chemical producers, and by fabric manufacturers; and to him is given the opportunity, as I see it, to correlate into the finished fabric the results of all these researches. And so his research, such as it may be, consists of testing, of carrying tests into plant procedures, of correlating plant results with his own tests, and of maintaining a friendly and constant contact with all of these other sources that provide him with the basic facts.

Perhaps this would be an excellent opportunity for me to say, on behalf of a good many dyers and finishers, how grateful we are for all of that research to which we fall heir.

Q: Does the pilling tendency of Dacron limit its use?

A: I think that the pilling tendency of Dacron, the tendency of fibrous fuzz on the surface of a fabric to roll up into small balls, or pills, is only a temporary problem. Eventually a fiber should be produced that will reduce this danger. At present, our efforts are confined to two-ply rayons; as we have found it in single yarns, the problem is much aggravated.

Of course, the twist of Dacron yarns plays a very important part in controlling pilling.

NOTE: The discussion on the afternoon of October 18, 1951, ended here. Those questions that were not covered at the symposium were answered by mail later by the same panel members and will appear with answers in Part II, which will appear in the next issue.

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Ballardvale, Mass.

INTRODUCTION

THE wet processing of woolen fabrics under the best of conditions includes a variety of problems for the dyer and finisher. When piecegoods made from a blend containing clips, garnetted threads, old rags or other types of colored wastes are to be dyed, the dyer has an especially difficult problem. The production of merchantable goods in such cases requires a great deal of skill and ingenuity, especially when the various colored stocks in the blend do not readily strip down to the point where the required shade is readily obtainable. In such work there must be a compromise between a maximum stripping action to obtain the lightest possible color in the blend and maintenance of fiber quality in the wool. Then the dyer must skilfully apply dyestuffs selected for brilliance and purity of hue. Fastness requirements may further complicate the situation by limiting the number of dyestuffs that may be used. The total cost of labor, chemicals and dyes is always an important consideration in these operations.

Over the years our dye-application laboratory has worked on problems which involved an investigation of the stripping possibilities of stock blends and piece goods including every type of reworked and reused fiber. The development of the Ogden Process originated during a routine task which was complicated and difficult because of the presence of dyed fibers that resisted stripping. In fact, some of the colors came out of the strip bath without much change in depth or hue. This raised a question which can be stated as follows:

Will the colors that are so resistant to stripping be equally resistant to stripping agents in a dye bath? After all, conditions in the stripping bath and the dyebath are very much alike except for the absence of stripping agent in the latter. Both baths are acid, both operations are carried on at the boil in the same kettle, and the time element is not very different.

If it is practical to combine the two operations, the result would be the elimination of the stripping operation as now carried out before the dyeing of wool stock or fabric. This operation requires normally a 30-minute boil and a thorough rinsing, which are about equal in time to a dyeing operation. In addition to the valuable saving of time from elimination of separate stripping, there would be gains in fabric strength and fiber quality in pieces containing large amounts of reworked and reused fiber.

The above considerations naturally led to a decision to investigate the possibilities of a combination process. It seemed logical to proceed on the basis that it was a dyeing problem for the dye laboratory rather than a search for relationships between dyestuff structure and effect of stripping agents.

F A Prisley

The Ogden Process is a procedure for stripping and dyeing woolen materials simultaneously. It has been found that under suitable conditions satisfactory results may be obtained by dyeing and stripping reused and reworked materials in one bath. The procedure in use before the development of th Ogden Process consists of stripping followed by a wash and often by neutralization in a new bath. The goods are then redyed in a fresh bath. The Ogden Process may be used to eliminate one, and in some cases, two of these three baths.

STRIPPING AND DYEING SIMULTANEOUSLY

EXPERIMENTAL——It was soon found that, as might be expected, dyestuffs fall into no sharply defined categories but may be classified generally as follows:

1) Colors that do not strip readily from dyed fiber in a strip bath and resist stripping agents in a dye bath.
2) Colors that do not strip readily from dyed fiber in a strip bath but are broken down by stripping agents in a dye bath.
3) Colors that strip readily from dyed fiber in a strip bath but resist stripping agents in a dye bath.
4) Colors that strip readily from dyed fiber in a strip bath and are broken down by stripping agents in a dye bath.

At this point, since suitable dyestuffs could be found to resist stripping agents and to satisfy other requirements, such as fastness to light, fastness to fulling for dyed stock, leveling, etc, the search for practical methods began. Representative fabrics and stocks with the shades being dyed on them by the mills were obtained. This phase took up a great deal of time, and there remain still a few problems involving certain unusual conditions, but a method can be stated at this time which generally works.

OGDEN PROCESS——For stripping and dyeing pieces the goods are prepared and loaded into the kettle as usual. Chemicals are added to the cold bath in the following order:

Dyestuff
Acid
Strip

The bath is brought to the boil in an hour and is boiled 30 minutes. At this point 10% of anhydrous sodium sulfate, owf, is added, and boiling is continued for 45 minutes. The goods are then washed.

CHOICE OF ACID——The acid used depends on the type of dyestuff; in this respect the process follows normal dyeing procedures. The stripping action does not ordinarily vary critically with the kind of acid

* Presented at the 30th Annual Convention at the Hotel Statler in New York, N Y on October 17, 1951.

† Patent applied for.

in the bath. There are occasions when consideration must be given to the behavior of certain dyestuffs to be stripped from the fiber in selecting the acid.

Generally, it has been found that each procedure, dyeing and stripping, works about the same in the combined operation as when carried out in separate baths. For example, if goods require a preboil with ammonia to get the best possible bottom in stripping before dyeing, then the preboil is necessary for the same result by the Ogden Process.

Toning to shade is carried out in the usual manner.

No claims are made at this time that the stripping or dyeing results are superior to results obtained by the normal procedure.

The light fastness of colors used to date seems to be equal to that when they are dyed normally.

STOCK DYEING——The dyeing of stock is handled as follows: The goods are loaded as usual and dyestuff and acid are added to the cold bath. The temperature is raised to 180°F, the strip is added, and the temperature of the bath is brought to the boil. More acid is added to the boiling bath and boiling is continued for 30 minutes. Chrome is added and boiling is continued for 30 minutes more. The stock is washed in the usual manner.

The fulling fastness shows no variation from that obtained by usual methods of handling. As in the case of the piece dyes, if certain stocks require an alkaline preboil in order to get certain shades, then it is included in the Ogden Process.

The above methods have been employed in several mills on plant-scale production on various kinds of fabrics and stocks. It was found in general that the same correlation was obtained as when laboratory formulas are translated to plant scale-production.

SUMMARY

The Ogden Process has been developed for the simultaneous stripping and dyeing of woolen piece goods and stock.

The results have been found to be satisfactory in practical operations.

The use of the Ogden Process eliminates the necessity for stripping piece goods or stocks before dyeing.

No expensive, hazardous, or unusual chemicals are required.

The Process may be employed in any equipment now in use for stripping and dyeing pieces or stock separately.

The savings in time of operation and in quality of fabric and fiber are considerable.

(A patent application has been filed and licensing agreements are available.)

DISCUSSION

Question: Does any particular type of stripping agent have to be used in this process?

Answer: Formaldehydesulfoxylate is employed, either the insoluble zinc type or the water-soluble sodium type.

Q: Would you tell us more about suitable dyestuffs for the Ogden Process?

A: Not all dyestuffs are suitable; the right ones must be found by experiment, whether acid or chrome.

Q: Can those acid dyes be employed that are suitable for colored discharge printing?

A: Generally speaking, but not always.

Membership Applications—

(Concluded from Page P250)

ganic Chem Dept, E I du Pont de Nemours & Co, Wilmington, Del.

Raymond G Eisenhard — General Mgr Goodwill Mfg Co, Atmore, Ala.

James E Flegal—Assistant Chemist, Peerless Woolen Mill, Rossville, Georgia.

Clarence E Gibson — Product Engineer, Dow Corning Corp, New York, N Y.

William D Grafton—Sales, Calco Chemical Division, American Cyanamid Co, Bound Brook, N J.

Sylvan L Handen—Asst Dir of Lab, National Plastic Products Co, Odenton, Md.

Kenneth W Hays — Associate Research Chemist, Callaway Mills Co, La Grange, Ga.

Edgard M Neves—Dyes Salesman, Sintesia Industria Quimica S/A Rio de Janeiro, Brazil.

Raymond J Picard—President, Rhodia, Inc, New York, N Y.

Cesare Poggi — Chemist, Mira Lanza SPA, Genova, Italy.

William H Roeper—Nite Supt Bleachery, Fulton Bag & Cotton Mills, Atlanta, Georgia.

Andrew B Shaw—Foreign Relations Rep, E I du Pont de Nemours & Co, Inc, Wilmington, Del.

Phillip L Slayton—Tech Sales & Sales, Monsanto Chem Co, Chicago, Ill.

Delmore E Smith — Purchasing Agent, Lilly Varnish Co, Indianapolis, Ind.

STUDENT

Bobby G Barnhill — Clemson College. Sponsor: J Lindsay, Jr.

James L Bridgeman — Clemson College. Sponsor: J Lindsay, Jr.

Zeddie L Collins—Clemson College. Sponsor: J Lindsay, Jr.

Heyward C Hurt—Clemson College. Sponsor: J Lindsay, Jr.

Eugene H Lehman — Clemson College. Sponsor: J Lindsay, Jr.

William F Moore, Jr—Clemson College. Sponsor: J Lindsay, Jr.

Cecil H Peppers—Clemson College. Sponsor: J Lindsay, Jr.

Paul N Robinette — Clemson College. Sponsor: J. Lindsay, Jr.

Arthur L Watson — Clemson College. Sponsor: J Lindsay, Jr.

Lewis P Bratton—North Carolina State College. Sponsor: H A Rutherford.

Chia-Lo Liu—North Carolina State College. Sponsor: H A Rutherford.

Carroll B Poplin—North Carolina State College. Sponsor: H A Rutherford.

David A Quails—North Carolina State College. Sponsor: H A Rutherford.

James L Sartin, Jr—North Carolina State College. Sponsor: H A Rutherford.

Robert H Blum—Philadelphia Textile Institute. Sponsor: W H Hughes.

Warren S Clapp—Philadelphia Textile Institute. Sponsor: W H Hughes.

David Heller—Philadelphia Textile Institute. Sponsor: W H Hughes.

David A Manderbach—Philadelphia Textile Institute. Sponsor: W H Hughes.

Theodore Vogel — Philadelphia Textile Institute. Sponsor: W H Hughes.

Vincent J Shanahan—New Bedford Textile Institute. Sponsor: F Tripp.

Leonard O Hinton, Jr—Georgia Institute of Technology. Sponsor: C A Jones.

Tristan A Laurion—Lowell Textile Institute. Sponsor: E E Fickett.

CORPORATE

Charlotte Chemical Laboratories, Inc.
Gaston County Dyeing Machine Co.
Dow Corning Corporation.

APPLICATION FOR TRANSFER TO SENIOR MEMBERSHIP

Merlen C Bullock
Benjamin H Brinkley, Jr
Andrew W Goodwin
Sydney Greaves
Nils W Janson
Marguerite P Kearns
Daniel T Koshak
David Leshin
Clarice Lindsey
Louis J Manara, Jr
Frank L Moskal
Richard B Simon
Roger G Stevens
Albert E Stutzke
Charles R Trommer

—◆ ◆—

CORRECTION

Re: "A Review of Flame-Resistant Treatments"

ON PAGE P135 of the March 3rd issue, it is stated, "In our own plant laundry where we wash welders' and lead burners' coveralls treated with Pyroset DO Fire Retardant, we get up to 32 washings without any loss in fire retardancy, . . .". The statement should correctly read "Pyroset D Fire Retardant."

K H Barnard, author of the article, is with the Textile Resin Department, American Cyanamid Company.

ABSTRACTS

The Dyeing of Blends Containing Regenerated Protein Fibers

C P Tattersfield, *Brit Rayon & Silk J* 28, No 330, 64, 66; No 331, 53, 54 (1951).

Regenerated protein fibers today are of three main types:—regenerated casein, e g, Fibrolane and Lanital; regenerated peanut protein, e g, Ardil; and regenerated zein (corn protein), e g, Vicara.

In all instances the natural protein is purified and brought into solution by alkali. This is then extruded into an acid solution whereby the fiber is coagulated in fibrous form. From this stage various processes and treatments follow in order to improve the properties of the fibers. These may include stretching, hardening with formaldehyde, hardening with salt solution or solution of salts of metals, such as aluminum or zinc. It is therefore apparent that fibers with properties that are similar to one another but differing in detail are being made or may be produced.

The fibers are soft, warm, and resilient. They are not suitable for use alone in fabric form but are used as such in fillings and waddings. In cloth they are normally associated with cotton or viscose rayon staple to improve the handle and crease-resistance and provide dyeing effects; they are associated with wool on account of their effect on the felting of wool; also in order to improve the "quality" of the lower grade wools; and to reduce costs. The regenerated fiber often increases the rate of felting, and in hat manufacture a firmer hood is produced.

Regenerated protein fibers have an affinity for all classes of dye, so that it is difficult to find a range of tints easily removable. Certain acid dyes (e g, Indigo Carmine and Acid Orange 2G) have proved most satisfactory.

If vat or sulfur dyes are used for dyeing, the alkalinity, temperature and time should be as low as possible. Sulfur dyes should be reduced with hydrosulfite, not with sulfide.

Level-dyeing acid dyes should be applied to blends of natural and regenerated protein fibers, with the assistance of 2-4 per cent formic acid rather than sulfuric acid. The usual amounts of Glauber's salt (10-20 per cent crystals) should also be present in the dyebath. At low temperatures it will be observed that the dyestuff is readily taken up by the regenerated fibers, while the natural fiber is dyed very little. At higher temperatures also the color exhausts first onto the regenerated fibers, but with continued dyeing migration takes place from these to the wool via the dyebath.

Where brightness of shade and wet fastness are required, fast-to-milling acid dyes are very satisfactory. They should be applied from a neutral bath, or one acidified slightly with ammonium sulfate or acetic acid.

Premetallized azo dyes, best known under the trade name "Neolan", are readily taken up by regenerated protein fibers. It will be found that many of these dyes are absorbed readily from neutral dyebaths. The rate of dyeing is increased by additions of salt or ammonium sulfate.

The after-chrome process may be used, but suffers from the disadvantage that a number of the dyes, before chroming, are sensitive to formaldehyde, which is present in the fiber. If a metal has been used in the hardening process in the production of the fiber, this may combine with the chrome dye to yield an abnormal shade. With the metachrome method of dyeing, destruction of dye due to formaldehyde does not usually occur, the sodium chromate acting as a protecting agent.

The fastness to light of chrome dyes, whether applied by the afterchrome or metachrome method, is virtually the same on the regenerated fibers as on wool.

For blends of regenerated protein fibers and viscose, direct cotton dyes are an obvious choice, especially since they are readily taken up by both fibers. The fabric should be as nearly neutral as possible. Addition of salt and decrease of temperature favor the dyeing of the viscose. With direct dyes sensitive to reduction, the addition of a suitable oxidizing agent to the dyebath may be necessary to prevent evolution of formaldehyde from destroying the dye.

Vat dyes applied under normal conditions tend to dye the cellulosic fiber more fully than the protein fiber, whereas the solubilized vat dyes tend to dye the protein more fully.—WHC

Monopole Oils

C Griffiths, *Dyer* 106, 875-6, Dec 28, 1951.

The monopole oils were originally introduced in Germany some 20 years ago as products showing certain improved properties over the ordinary sulfated oils, particularly turkey-red oil.

Sulfated oils are made by treating an animal or vegetable oil with sulfuric acid at carefully controlled temperatures, washing out the excess acid, and neutralizing the sulfated oil with soda, ammonia, or potash. During sulfation, and more particularly during the washing process, part of the glyceride of the fatty acids of which the oil consists is hydrolyzed, with the resulting liberation of free fatty acid. This free fatty acid is subsequently at least partly neutralized, with the result that the finished oil contains a certain proportion of soap. A sulfated oil is, therefore, generally a complex mixture which, ignoring lactone formation and polymerization, consists of

(a) Sulfated glyceride.
(b) Unsulfated glyceride.
(c) Sulfated soap.
(d) Unsulfated soap.
(e) Free sulfated fatty acid.
(f) Free unsulfated fatty acid.

A normal turkey-red oil generally contains 40 per cent of oil in the glyceride state and 60 per cent in the form of free fatty acid and soap.

It is possible, by altering the proportion of acid to oil, the sulfation temperature, the washing temperature, reaction time and other factors, to alter the extent to which the glyceride is hydrolyzed, and hence the proportion of soap and free fatty acid in the finished oil. What is most important is that it is possible, at the same time, to increase the proportion of free unsulfated glyceride, the so-called "neutral oils", in the finished oil, and yet increase the total degree of sulfation. The importance of this to the textile finisher is obvious. Since he is generally using the oil as a softener, the presence of a high proportion of neutral unsulfated oil enables him to obtain better softening results with the same weight of oil, or alternatively, the same degree of softening with a reduced weight of oil, and consequently achieve an appreciable economy.

This is the basis of the improved properties of the monopole oils; though sulfated to a higher degree than turkey-red oil, they possess a much higher proportion of neutral oil. Because of their higher degree of sulfation they are stable to organic acids (turkey-red oil is not), and have improved stability to hard water. They may be readily distinguished from a normal sulfated oil by adding acetic acid to an aqueous solution of the oil. Monopole oils are perfectly stable; the ordinary type of sulfated oil gives immediately an oily precipitate.

The author points out that monopole oils are not confined to castor oil. The monopole type of oil can be produced with almost any animal and vegetable oil, and one of the earliest German products, Monopole Brilliant Oil SO, was a sulfated olive oil.—WHC

• PATENT DIGEST •

PAUL WENGRAF

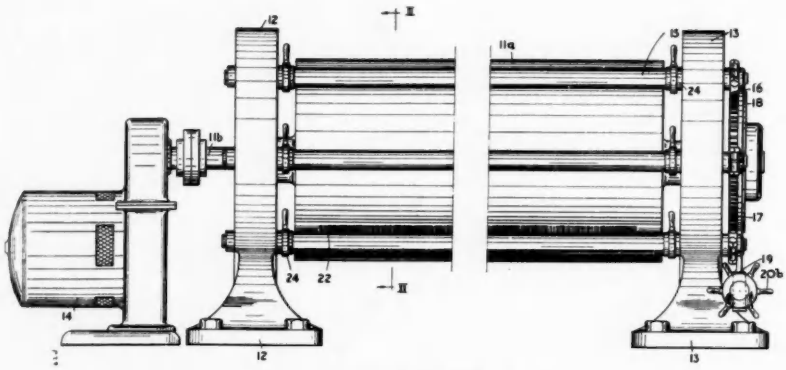


Figure 1—USP 2,569,897

FINISHING TEXTILES—— Applying Smooth Pressure by Rows of Resilient Blades G, 4

U S Pat 2,569,897
(Bleacher's Association Ltd—Melville—
Oct 2, 1951)

The customary calenders, rollers and the like that are used in finishing woven cotton fabrics have the disadvantage of flattening the warp and filling, causing the fabrics to lose their characteristic appearance because of the glaze produced. This effect is especially undesirable in finishing fabrics of the cambric or poplin type.

The purpose of this invention is to preserve the natural aspect of the woven structure. This is accomplished by applying smoothing pressure through a set of resilient combs upon the threads lying on the outermost surface of the fabrics and, at the same time, upon the channels formed between these threads. In contrast to the usual calendering effect, a distinctive, discontinuous luster finish is said to be produced.

Rows of thin, closely-spaced, resilient, smooth-end blades slide over the fabric. Commonly 1″ long, 0.008″ thick and 0.125″ wide and preferably of stainless steel or synthetic phenol-aldehyde resin composition, the blades are inserted in spindles to produce a large number of polished surfaces on the threads and in the furrows between the threads. Figure 2 shows a sketch of how the blades are resiliently mounted in a rubber block. Figure 1 shows the arrangement of the blades against the fabric. A series of spindles [15], carrying the blades [22], surrounds the fabric [25] coming from [25a], transported by roller [11] and wound up on [25b] (See Figure 3). The blades, normally inclined at an angle of 45—75° to the surface of the fabrics, can be adjusted to the desired angle by a circular member in the form of a gear-wheel, which meshes with arcuated racks.

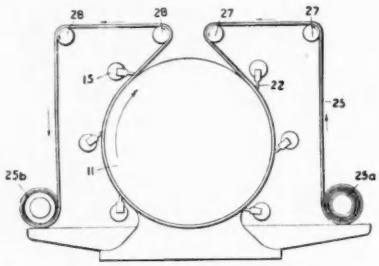


Figure 3—USP 2,569,897

Although the comb-like elements are generally stationary, a rotatory movement (effected by mounting the rows of blades on rotating rollers instead of the fixed spindles) is within the scope of this invention.

Among other references cited by the Patent Office:

USP 2,356,964 (Alderfer, Andrews /1944): a loom particularly adapted for weaving narrow fabrics, such as tapes, webbing or similar materials. The twist imparted shows on both sides.

USPat 2,180,745 (Progressive Silk Finishing Co/1939): a method for decorating ribbons. They are passed between a pair of scratch rollers, whereby the filling threads are displaced, and are then run through pairs of intermeshing rib rollers where a design is applied uniformly on both sides.

USPat 922,488 (Sächs Haushaltungs Ges /1909): a pneumatic mangling roller combined with a pump. The roller consists of a hollow rubber body into which air can be pressed by the pump.

USPat 872,489 (Whitney/1907): a hide-working machine essentially composed of a metal-core roller covered with a hard rubber layer.

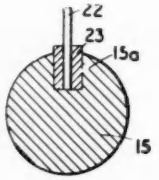


Figure 2
USP 2,569,897

French Pat 422,393 (Galy/1911): a napping device. The textile passes over two rollers, the first carrying steel blades that are adjusted to raise the filaments without impairing the tensile strength, and the second employing a rotating brush.

DYEING NAPHTHOL DYES—— Crocking Fastness Improved by Vinyl Resin Aftertreatment C, 4, 03

U S Pat 2,575,026
(Monsanto Chem Co—Rossin—
Nov 13, 1951)

While naphthol dyes (i e, insoluble azo dyes in general) have excellent wash- and light-fastness, their resistance to crocking is considered relatively poor.

According to this patent, the rubbing fastness of cellulosic fibers that are dyed with this class of dyestuffs can be improved by an aftertreatment with a water-soluble or water-dispersible ammonium-, amine- or amidated salt of a vinyl copolymer, with an ethylene α-β-dicarboxylic anhydride (such as maleic anhydride), or a half ester thereof. The vinyl component, R—CH:CH_2, contains phenyl or substituted phenyl. The fastness can be improved further by adding formaldehyde resin condensates (5-20% of the copolymer). The simplest case mentioned in this specification is a copolymer of styrene with maleic anhydride, polymerized either in emulsion or in an organic solvent for the components (e g, xylene) wherein the final product is insoluble after copolymerization. The copolymers are thereafter dissolved or dispersed in ammonia. The procedure consists of naphtholating the fabrics as usual, coupling with a diazotized base or a stabilized diazo compound (such as Fast Scarlet Salt RN (C I #118) and immediately thereupon padding in the ammonia solution of the above-mentioned copolymers. After

drying at 250°F the dyed fabric is said to show excellent fastness to crocking, which persists after repeated laundering operations.

The advantages of this method are twofold: 1) the azo-dyed material does not have to be soaped, rinsed or dried before passing it through the solubilized after-treating copolymer, and 2) dulling, which generally occurs in the drying of diazotized fabrics, is reportedly overcome.

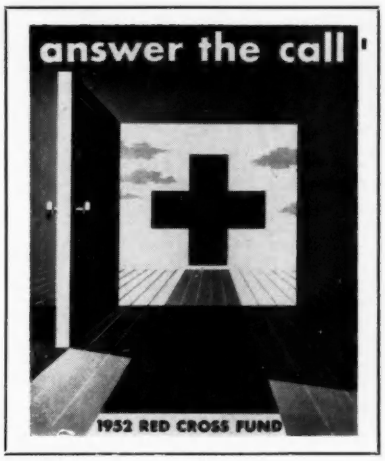
A table indicates several useful combinations of naphthol developers, such as Naphthol AS, Naphthanil AS-D, etc, with fast color bases or salts. Brit P 659,078 (Monsanto), cf *Am Dyestuff Reptr 41,* 118 (1951), refers to the same type of solubilized copolymers for improving the crock fastness of pigments in dyeing and printing processes.

Among other references cited by the Patent Office:

USP 2,416,884 (Du Pont/1947): improvement of dye fastness by applying nitrogen compounds containing two N- atoms attached to a CH_2- group (cf *Am Dyestuff Reptr 36,* 338, 1947).

USP 2,356,879 (Pense, et al/1944): preparing lustrous coatings on leather by applying alkali- or ammonia-solubilized copolymers of styrene-maleic anhydride or vinyl-maleic anhydride copolymers combined with pigments.

USPat 2,322,333 (Ciba/1943): improving the fastness of direct dyeings by aftertreating with formaldehyde precondensates of urea, phenol, guanidine, melamine, etc.



NEWS

Leon E Moody

• CATCC Forum and Exhibit Receiving Considerable Response

The Textile Fastness Testing Forum and Exhibit being sponsored by the Canadian Association of Textile Colourists and Chemists, Quebec Section in Montreal on April 25, 26 is reportedly receiving enthusiastic response from the trade. The exhibit and forum, first of its kind in Canada, is being held in conjunction with the annual meeting of the association. The Sheraton Hall and Palm Court of the Mount Royal Hotel have been reserved for the two-day event.

Designed to further the important work of the CATCC on standardizing test methods in the primary textile industry, the exhibit and forum will be open from noon on Friday, April 25th, to 4:00 pm, Saturday, April 26th.

In addition to the regular 400 CATCC members, it is anticipated that at least an equal number of invited guests, including additional textile industry executives, purchasing agents and sales personnel, as well as department store buyers and representatives of testing, laboratory and consumer textile groups, will be on hand.

Speakers who will lead discussion at the Friday evening fastness forum will represent research, dyeing, finishing, sales, purchasing, testing and consumer textile groups.

Leon E Moody, Duplan Dyeing Co Ltd, Valleyfield, Que, is exhibit chairman, and Clarkson-Conway Associates, Suite 18, Mount Royal Hotel, Montreal, Que, are handling exhibit arrangements. Chairman of the test methods committee of the CATCC is E V Burnthall, Ciba Co Ltd.

• AOCS to Meet April 28-30

Arrangements for the 43rd annual meeting of the American Oil Chemists' Society, to be held at the Shamrock Hotel, Houston, Texas, April 28-30, are almost complete, according to William Argue, general chairman. More than 30 technical papers are scheduled by the Program Committee, of which Prof J D Lindsay of Texas A & M is chairman.

Results of the election of officers by mail balloting will be announced at the meeting by A E Bailey, president.

Patricia Ann Mullarkey, Maid of Cotton for 1952, tests a "heat-resistant" ironing board cover, made of cotton fabric produced by a chemical process developed at the Southern Regional Research Laboratory in New Orleans, La, during her recent visit. The cover is made of "acetylated" cotton, which is said to outlast ordinary cotton several times over. Besides exceptional resistance to damage from heat, "acetylated" cotton reportedly resists rot and mildew much longer than ordinary cotton. The apron being ironed is made of fertilizer bag material.

Mona Textile Psychometer

• Mona Moisture Meter

A recent development of recently-formed Mona Industries, Inc (65-75 E 23rd St, Paterson, N J) is the Mona Moisture Meter, an electronic, portable instrument for measuring the moisture content in fibers, silver, roving, yarn and fabric during all phases of production. It reportedly measures accurately and immediately, within a tolerance of .5%.

Suitable to all type fibers, the instrument is said to be sufficiently rugged to withstand routine abuse in the mill. Standard dry cell batteries are used to avoid variations in line voltage.

Weight: 4 lbs. Measurements 7½" x 5¼" x 3 1/3".

• Five Americans Elected to Textile Institute

Five Americans are among the textile experts from all parts of the world who were recently elected to Fellowship and Associateship of the Textile Institute, international organization of textile technologists.

The new Fellows include George S Buck, Jr, technical director of the National Cotton Council of America; Dr Walter M Scott, assistant chief, Bureau of Agricultural and Industrial Chemistry, U S Dept of Agriculture; and Dr Emery I Valko, research consultant.

New Associates include Ksawery Kowalski, textile chemist, Triangle Finishing Corporation and R E Seaman, Rayon Dept, E I du Pont de Nemours & Co, Inc.

• New Kearny Representatives in Canada

Messrs Ian M Haldane & Co, P O Box 54, London, Ontario, have been appointed representatives of the Kearny Manufacturing Company, Kearny, N J, for the Dominion of Canada, it is learned.

A number of original prints of French dyeing methods and equipment used in earlier days were featured by Standard Chemical Products, Inc (Hoboken, N J) at the 3rd Annual Textile Symposium of Fairleigh Dickinson College. The prints, which are owned by the company, are originals made in France a generation prior to the Revolution. Many have been reproduced in a brochure prepared by The Stuart Company, 50 Church St, New York 7, N Y, for Standard Chemical. Copies may be obtained upon written request.

• Celanese to Discontinue Dyeing and Finishing Plant

Celanese Corporation of America has reoriented its woven fabric manufacturing operations, resulting in a reduction of weaving, dyeing and finishing productive capacity and permitting a greater concentration on the creation and development of new markets and new uses for acetate fibers, either alone or in blends with other chemical or natural yarns, Harold Blancke, president, recently declared.

The statement supplemented a company announcement at Cum erland, Maryland, disclosing that the dyeing and finishing plant is to discontinue operations this Summer. Such activities, which have been a subsidiary operation to the major function of acetate fiber production at Cumberland since 1925, reportedly will be consolidated into the integrated dyeing and finishing plant at Hopewell, Virginia, which possesses newer and more modern equipment.

• Portable Electric Reciprocating Stirrer

For the thorough, regular agitation of liquids in vessels of relatively small diameter, such as may be used in molecular weight determination by the boiling or freezing point method, the Research Appliance Company (Box 413, West View Rd, Pittsburgh 9, Pa) recommends their portable electric reciprocating stirrer.

The product reportedly may be used in obtaining data on cooling curves where stirring should be constant and over a long period of time. The length of stroke may be varied (e g, 1", 1½", 2") by adjusting the position of the small screw. Dimensions: 9", 4", 8". Weight: 4.8 lbs. 110 v 60 cycle a c, 120 rpm.

• Hercules Increases "Hercoflex" Production

Hercules Powder Company has upped capacity for the production of "Hercoflex" vinyl plasticizers 40 per cent to meet customer demand.

These plasticizers are manufactured by Hercules at Mansfield, Massachusetts, and were first introduced to the trade in 1949. Hercoflex 150 and Hercoflex 250 are primary phthalate-type plasticizers.

The increase in plasticer output makes a third plasticizer, Hercoflex 290, available for the first time in tank car quantities. Hercoflex 290 is the adipic acid ester of a blend of straight chain octyl and decyl alcohols.

Technical information on Hercoflex plasticizers is available from Hercules' Synthetic Department in Wilmington, Delaware.

OBITUARY

NELSON M SMITH

NELSON M SMITH, retired manufacturing executive and the last surviving son of Robert P Smith, one of the founders of Smith, Drum and Company, died Friday, March 14, at the Albert Einstein Medical Center, Northern Division. He was 56.

Prior to his retirement, Mr Smith was active in the Sales Departments of the Textile and the Laundry Divisions of Smith, Drum.

He is survived by his wife, Clara M Smith; a son, Robert Nelson Smith, vice president and treasurer of Smith, Drum & Company; and a daughter, Mrs J Howard Kennedy.

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